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IS 15475 (Part 3) : 2022

Indian Standard

मनोरंजन के लिए सुरक्षित सवारी की संस्तुत रीति संहिता

भाग 3 डिज़ाइन, निर्माण और स्थापना

(पहला पुनरीक्षण)

Code of Recommended Practice for Amusement Rides Safety

Part 3 Design, Manufacture and Erection

(First Revision)

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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in   www.standardsbis.in

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Continuous Bulk Conveying, Elevating, Hoisting Aerial Ropeways and Related Equipment Sectional Committee, MED 6

FOREWORD

This Indian Standard (Part 3) was adopted by the Bureau of Indian Standards, after the draft finalized by the Continuous Bulk Conveying, Elevating, Hoisting, Aerial Ropeways and Related Equipment Sectional Committee had been approved by the Mechanical Engineering Division Council.

Amusement parks in India are becoming quite common and people visit these parks quite often. In order to ensure their safety in amusement parks or while enjoying the rides, an attempt has been made to stipulate safety in the form of a National Code. It is hoped that organizers of amusement parks, manufacturers of rides would make use of these codes to ensure the overall safety of human beings and equipment at such places.

This revision has been taken up to keep pace with the latest technological developments and international practices. This revision incorporates the following major changes:

a) More safety provisions were added with new clauses **5**, **6** and **7**.

The code of recommended practice for amusement rides safety is in six parts. This standard covers the requirements which need to be considered during the design, manufacture, and erection of amusement rides. Other parts in this series under the general title are as follows:

Part 1	General information
Part 2	Safety requirements
Part 4	Selection, training, and supervision of operators
Part 5	Operation and maintenance procedures
Part 6	Performance tests

Considerable assistance has also been derived from the following Standards for Safety of Amusement rides and amusement devices:

ISO 17842-1 Safety of amusement rides and amusement devices — Part 1 : Design and manufacture

ISO 17929 Biomechanical effects on amusement ride passengers

This standard is not intended to contravene the provision of any of the existing Government regulations. It is the responsibility of the user of this code to establish appropriate safety and health practices and comply with regulatory and statutory requirements prior to the use of the ride or device for carrying a passenger for amusement.

The composition of the committee responsible for the formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded-off value should be the same as that of the specified value in this standard.

Indian Standard

CODE OF RECOMMENDED PRACTICE FOR AMUSEMENT RIDES SAFETY

PART 3 DESIGN, MANUFACTURE AND ERECTION

(First Revision)

1 SCOPE

This standard (Part 3) covers information, parameters, requirements, and procedures for the design, manufacture, and erection of amusement rides and devices.

This standard does not contain rules to cover all the details of design, construction, or erection of ride or device. Where complete details are not given, it is the intention that the designer, manufacturer, subject to the approval of the user, and the inspecting authority shall follow such details of design, construction, and erection which will be safe for use of riders.

2 REFERENCES

The standards listed in Annex A, contain provisions which, through their reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards in Annex A.

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions, in addition to those given in IS 15475 (Part 1) shall apply:

3.1.1 *Inspector* — A person who, through education, experience, and/or training and certification by a competent agency is able to properly evaluate an amusement ride or device to determine its conformance with related codes/specifications.

3.1.2 *Inspecting Authority* — Duly authorized representative of the purchaser or any other competent authority recognized by the statutory regulations to inspect the amusement ride or device and determine its acceptability or otherwise on the basis of appropriate Indian Standards or accepted safety requirements.

3.1.3 *Statutory Requirements* — The measures that must be taken to comply with any Governmental codes, regulations, ordinances, or rules that are applicable to an amusement ride, amusement device, or joy park.

4 REQUIREMENTS FOR DESIGN ANALYSIS AND EXAMINATION

4.1 Design and Manufacturing Drawings

These are required for all assemblies, subassemblies, and individual components, the fracture or failure of which might endanger the stability or operational safety of the device. The drawings shall feature all the dimensions and cross-section values required for testing and approval, including details of materials, structural components, fasteners, connectors, and also relevant speed. The drawings shall include as a minimum, as applicable:

a) General drawings in plan view, elevation, and sections, in a legible scale, depending on the size of the device; an indication of the necessary clearance around the moving parts;
b) Detail drawings showing all the structural subassemblies which are not clearly discernible on the general drawings, as well as detailed drawings of connections and individual items of a structural, mechanical, or electrical nature, which could affect the safety of the device and its operation, shall be drawn to a larger scale;
c) Illustrations of the following items may be necessary for this purpose:
    1) Slewing gear, hoisting and swiveling mechanisms, including their support arrangements, drives and controls, lifting and swiveling ranges;
    2) Carriages, gondolas, and similar, illustrated in all the required views and cross-sections, with details of the overall dimensions, the internal dimensions of importance to the passengers (seats, side, and back rests, leg and foot room), hand and foot

holds and locking and securing devices;
3) Motion gear with details of load, guide, and stop wheels, bearings, axles, shafts and their attachment, freedom of movement in relation to the vehicle, steering and control, anti-rollback devices, safety devices against derailment and overturning, buffers, trailer devices, protection devices, drives and brakes and anchoring to the foundation;
4) Pneumatic and hydraulic circuits and electrical and electronic wing diagrams.

4.2 Principles of Analysis

Verification shall comprise the following:

a) Ultimate limit states analysis;
b) Fatigue limit states analysis;
c) Stability limit states analysis, that is, bar buckling, plate, and shell buckling;
d) If required, verification of deformation limit states;
e) Verification of safety against overturning, sliding, and lifting off;
f) Dynamic analysis (excluding seismic analysis).

The afore-mentioned verifications shall include at least the following details:

a) Design loads, including unbalanced load, taking into account the possible operating conditions or alternative installations. In the case of moving parts, the velocity or the rotational speed and acceleration shall be stated. Special loads imposed during erection (for example, parts walked on which are not designed for that purpose) should be specified and listed for demarcation;
b) Main dimensions and cross-section values of all load-bearing structural components and details relating to the assessment of the fatigue strength;
c) Details of materials and components;
d) Determination of the most unfavourable (maximum/minimum stress and stress range) stresses and details relating to the strength of the load-bearing structural components and fasteners. If calculation seems insufficient to evaluate limit states of assemblies, the analysis may be replaced by testing;
e) Details of elastic deformations (flexure, torsion), when such details affect the stability or operating safety of the device;
f) Details of those structural components that require special examination and inspection in accordance with verification of strength.

4.3 Selection of Materials

a) Steels for structural components Steels used for structural components should be in accordance with IS 2062 for any special steel that may be used;
b) Aluminum alloys shall be selected in accordance with Indian standards IS 1285, IS 5384, IS 8147, IS 734;
c) Timber Selection, design, and use of timber shall be in accordance with Indian standards IS 3629, IS 883, IS 399;
d) Plastic composites Selection of plastic composites shall be in accordance with applicable Indian standards IS 2828, IS 9833, IS 14534;
e) The selection of concrete grades shall be in accordance with Indian standards. IS 456
f) Fasteners for structural components Bolts, screws, and studs shall be in accordance with Indian standard IS 1368. For machinery and mechanisms, other bolts according to appropriate standards may be used;
g) Standards relating to ropes, chains, safety devices, connectors, and adapters In addition to the calculation of the load-bearing capacity of materials or accessories, which relate directly to the safety of passengers or public, certificates, manufacturer’s markings, or testing shall also be provided. When ropes, chains, safety devices, connectors, and adapters are used, the following standards, in particular, should be observed:
    1) Steel wire ropes : IS 2266
    2) Termination for steel wire ropes : IS 2485
    3) Clamps for wire ropes : IS 2361
    4) Components for slings : IS 2762
    5) Shackles : IS/ISO 2415
h) Fibre ropes for general service — Determination of certain physical and mechanical properties as per IS 3871, IS 9936, IS 5175;
j) Natural fibre ropes, Manila and sisal. 3, 4 and 8 strand ropes as applicable by IS 3871;
k) Fibre ropes for general service — Hemp : IS 11066 (Fibre ropes- Polyester);
m) Chains used should be as per IS 2760, IS 2429, IS 3109, IS 1834, IS 3077 and IS/ISO 3076.

4.4 Design Parameters

4.4.1 *Passenger Weights*

For design purposes weight of passengers may be considered as follows:

Adult = 85 kg or 6.07 kg/25 mm of hip width at the seat;

12-year child = 45 kg or 4.5 kg/25 mm of hip width at the seat (Height 140 cm for the adult ride)

4.4.2 *Metal Structures*

For the design of metal structures, the various loads and stresses that can occur during the operation of the ride shall be considered but not limited to the following:

4.4.2.1 *Deadload*

Load forces of all fixed and movable construction parts, always present in the operation of the mechanical and electrical plants as well as the support structures.

4.4.2.2 *Passenger load*

A load of passengers and devices (seat and support) depending on the capacity of the ride and direction of travel.

4.4.2.3 *Permanent dynamic effects*

The dynamic effect of falling load at transfer points and rotating parts of the ride.

4.4.2.4 *Load due to inclination*

Loads due to the inclination of working-level and machines/passengers.

4.4.2.5 *Wind load*

Aerodynamic pressure depending on the local conditions and wind speed.

4.4.2.6 *Temperature*

The temperature effect may be considered when materials with very different expansion coefficients are used within the same component.

4.4.2.7 *Resistance due to friction and travel*

Frictional resistances be considered if they influence the sizes related to travel.

4.4.2.8 *Failure of safety devices*

Additional load due to the failure of safety devices provided to limit the useful load may be taken into consideration.

4.4.2.9 *Forces of ride*

Belt tensions, chain tensions, etc, shall be taken into consideration for the calculation as far as they have an effect on the structure.

4.4.2.10 *Wind load on the non-operating element*

Wind speed and aerodynamic pressures with reference to the above-ground height of the structural element.

4.4.2.11 *Buffer effects*

The reaction of the structure to collision with buffers at higher speeds.

4.4.2.12 *Locking of traveling devices*

Rail mounted equipment may be blocked by derailment or rail fracture. The maximum drive effect may be taken into consideration.

4.4.2.13 *Loads due to earthquakes*

Effects due to earthquakes may be considered in calculation as special load.

4.4.2.14 *Erection loads*

In certain cases, it may be necessary to check some structural parts under dead loads in particular mandatory situations.

4.4.2.15 Forces on passengers due to action of the ride based on design.

4.5 Design of Structural Parts for General Stress Analysis

4.5.1 *General*

The stresses arising in the structural parts shall be determined and checks shall be made to ensure adequate safety margin exists with respect to the following:

a) Straining beyond the yield point or the permissible stress;
b) Straining beyond the permissible crippling or buckling stress; and
c) Exceeding the permissible fatigue strength.

4.5.1.1 Conventional strength of materials calculation procedures shall be used to calculate the strength and suitable material shall be selected on the basis of their characteristic values. Allowable loads or stresses shall be reduced as deemed adequate by the designer/manufacturer to allow for special combinations of conditions which may include but are not limited to stress concentrations, shocks, dynamics, load cycles, degree of risk, and environment.

4.5.2 *Design of Joints*

4.5.2.1 *Welded joints*

In the case of combined stresses in one plane a comparative value shall be established for all types of welds and compared with allowable stresses. The weld joint shall have at least the tensile strength and yield point of the steel of the welded structural members.

4.5.2.2 *Bolted joints*

Holes for bolted and riveted joints shall be drilled and reamed. Tolerance in the hole shall be as per recommended engineering practices.

4.5.2.3 *Rivets*

The rivets shall not be subjected to tensile load.

4.5.2.4 *Joints using high strength friction grip (HSFG) bolts with controlled tightening*

These types of bolted joints are especially recommended for the joining of members subjected to dynamic loads and offer a guarantee against loosening.

5 DESIGN LOADS

5.1 General

In general actions, load, design as well as any structural assumptions for load-bearing parts of devices shall be chosen if so required due to the special nature of amusement rides and devices.

5.2 Permanent Actions

For amusement rides and devices in general a very precise assumption of permanent actions is possible. Where variations can occur, the values $G_{k,sup}$, and $G_{k,inf}$ shall be taken into account when assessing the most likely structural response. Elsewhere a single characteristic value G_k is sufficient. The values are defined as follows:

G_k	Characteristic value of permanent action;
$G_{k,sup}$	Upper characteristic value;
$G_{k,inf}$	Lower characteristic value.

Included in the above values are the actual dead load of the load-bearing structure, the accessories, and the technical equipment required for operation, including cladding, fabrics, and other decorative elements. The wet and dry condition of material is accounted for in $G_{k,sup}$, and $G_{k,inf}$.

The permanent actions shall be determined in accordance with international standards. The actual weight of machine components, electrical equipment, and passenger units like carriages or gondolas shall be verified.

5.3 Variable Actions

5.3.1 *Imposed Loads*

5.3.1.1 *General*

These consist of the external loads and imposed deformations (for example, imposed loads, gyroscopic loads, dynamic loads, wind and snow loads, temperature or settlement) acting on a structural component, which may vary in magnitude, direction, and point of application (variation in time and space) during normal operation.

5.3.1.2 *Vertically imposed loads*

a) Passenger-carrying units
On passenger-carrying units (vehicles, cars, gondola) the following loads shall be assumed.

Q_k is the characteristic value of the variable actions.

For each person over 10 years of age:

Q_k = 0.85 kN for all fatigue calculations;

Q_k = 0.85 kN for static calculations (non-fatigue) for more than 4 passengers per compartment except in the case below;

Q_k = 1.35kN – (n – 1) × 0.15 kN where $1 \leq n \leq 4$ for static calculation only and the load transferring members from the seat into center assemblies for individually supported or suspended seats with n = 1 to 4 passengers per single compartment.

NOTES

1 These static loads are not an operational and general weight limit or requirement and need not be used for overall calculations (for example, sliding, overturning, etc.) of the compartment or ride itself.

2 Using special compartments for larger persons the above-mentioned values of load assumptions shall be corrected.

3 The designer can consider possible higher weight depending on the seat configuration and type of ride.

For each person of 10 years or less:

Q_k = 0.45kN in both fatigue and static cases. Where the reduced loadings for the person of 10 years or less are employed the restrictions shall be clearly indicated at the ride and in the manual.

b) Other vertical loads
The following vertical imposed loads shall be applied for any area designed for access by foot.

Universal, public access:

q_k = 3.5 kN/m^2 for floors, stairways, landings, ramps, entrances, exits, and other similar features in rides and facilities;

q_k = 5.0 kN/m^2 for grandstands and their stairways and landings with fixed seats; and as a superior value, if particularly dense crowds are anticipated for the above-mentioned categories

q_k = 7.5 kN/m^2 for grandstands and their stairways and landings without seats or non-fixed seats; and as a superior value, if particularly dense crowds are anticipated for the above-mentioned categories

q_k = 2.0 kN/m^2 for the revolving or boom area walked on by the public during operation (load and unload); or twice the full passenger load of all passenger units and carriages according to (a), whichever is the more unfavorable, in order to make the necessary allowance for change of passengers.

Q_k = 1.0 kN/step for stairs; alternatively, an area load in accordance with the above clauses, whichever is the more unfavorable.

q_k = 1.5 kN/m^2 for seat boards of rows of seats per seat run and for floors between fixed rows of seats, unless higher loads result from the application of area loads (qk = 3.5 kN/m^2).

Not open for public access:

q_k = 1.5 kN/m^2 for all floors, platforms, ramps, staircases, catwalks, stages, and the like which are walked over by individual persons, or

Qk = 1.5 kN for individual loads, whichever is the more unfavourable.

5.3.1.3 *Horizontal imposed loads*

The following horizontal imposed loads shall be applied for parapets, fences, railings, wall panels, and other similar features:

When bounding floors intended for public access designed for q_k = 3.5 kN/m^2:

p_k = 0.5 kN/m at hand rail height;

p_k = 0.1 kN/m at intermediate rail height.

When bounding floors intended for public access designed for q_k = 5.0 kN/m^2 and

q_k = 7.5 kN/m^2;

p_k = 1 kN/m at hand rail height;

p_k = 0.15 kN/m at intermediate rail height.

When bounding floors not intended for public access designed for q_k = 1.50 kN/m^2 :

p_k = 0.30 kN/m at hand rail height;

p_k = 0.10 kN/m at intermediate rail height.

For wall panels where there is no special handrail, the above values shall be applied at handrail height, but, where appropriate, not higher than 1.2 m.

5.3.1.4 *Grandstands*

In order to achieve an adequate longitudinal and transverse stiffness in the case of grandstands and similar installations with seating or standing accommodation, a horizontal load acting at floor level in the most unfavorable direction in each case shall be entered in the calculation in addition to any eventual wind force in accordance with **5.3.4**. The horizontal component load shall be taken as 1/10 for temporarily installed and 1/20 for permanently installed grandstands of the imposed vertical load in accordance with **5.3.1.2 (b)**.

5.3.2 *Driving Forces and Braking Forces*

Driving forces and braking forces shall be calculated for the drive and brake selected (for example, d.c. motor, three-phase a.c. motor, hydraulic drive), and they shall be entered in the calculation at these values. In the case of hydraulic cylinders, the influences arising from start-up and braking shall be kept within manageable limits by suitable design measures and shall be taken into account in the calculation. In general, the braking and starting forces, B, shall be calculated according to the actual brake and motor performance (acceleration/deceleration):

$$B = a_b \times (m_v+m_p)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

where

a_b = braking/starting acceleration;

m_v= mass of moving parts without passengers;

m_p= total mass of passengers as per **5.3.1.2 (a)** above.

In the case of circular movements, the appropriate parameters shall be applied in the formula. Care needs to be taken to allow for speed reduction units (for example, transmissions; gearboxes). An eventual impact factor shall be taken into account.

In the case of speeds not exceeding 3 m/s, the driving forces and braking forces can be derived with a_b = 0.7 m/s^2, if a more precise evaluation is not carried out.

5.3.3 *Bracing and Restraint Loads*

Such loads shall be taken into account when designing passenger restraints and containment, railings, and bracing devices within the passenger unit. All significant situations during the ride cycle including loading, unloading, and emergency situations shall be considered. The allowance shall also be made for the forces caused by passengers bracing themselves against restraints and other parts of the containment (for example, footrests). The magnitudes of maximum bracing forces are dependent upon the detailed design of the containment and as a result of the passenger's deliberate actions. However, forces used in any calculations should never be less than 500 N per person.

5.3.4 *Wind Loads*

a) General
   In general standards for wind actions on buildings and structures shall be chosen in the following sequence:
   1) according to the provisions of IS 875 (Part 3);
   2) according to the provisions of IS 802 (Part 1).
b) Wind loads in limit state
   The wind loads for permanently installed amusement devices shall be taken from the IS 802 (Part 1) and IS 875 (Part 3).
   For temporarily installed devices, the values in Table 1 may be applied which defines the approximate the wind pressure in a step function.

Table 1 Wind Pressure Values for Temporarily Installed Amusement Devices

[C*lauses* 5.3.4 (b), 9.3.1 (b)]

Sl. No.	**Height of structure** z_e **m**	**Pressure $q(z)$ (kN/m^2) for reference wind speed**	
		$v_b \leq 15$ m/s (operating state)	$v_b \leq 28$ m/s (out of service)
(1)	(2)	(3)	(4)
i)	$0 < z_e \leq 8$	0.20	0.35
ii)	$8 < z_e \leq 20$	0.30	0.50
iii)	$20 < z_e \leq 35$	0.35	0.90
iv)	$35 < z_e \leq 50$	0.40	1.0

NOTES

1 Wind load for structures with a height of more than 50 m are not defined in Table 1.

2 Dynamic effects due to wind (gusts, buffering, vortex shedding) may occur at structures with low stiffness (low natural frequency).

The wind load, F_W, on a structure or part may be calculated by the application of the above values in the following formula:

$$F_W = Q(z_e) \times C_f \times A_{ref} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where

$Q(z_e)$ = wind pressure depending on height z_e;

C_f = aerodynamic coefficient;

A_{ref} = reference area. In general, the respective shape factors of particular structures and structural members shall be applied.

5.3.5 *Inertia Forces (Centrifugal Forces, Gyroscopic Forces, and Coriolis Forces)*

Inertia forces shall be determined according to the prevailing circumstances in each case.

5.3.6 *Intentional Collision During Operation*

The effects of collision loads need only be taken into consideration in respect of the structural components directly affected and their associated fixings. Collision shall be assumed to occur at the most unfavorable point of the structural component concerned, and the calculation shall be based on the mass of the fully occupied vehicle, motor, except when intentional collision only can occur with empty vehicles. If a collision can only occur at angles $\alpha \leq 90°$, the collision force F (in Newtons) shall be assumed to be

$$F = 9.8 \times M_{tot} \times Sin\alpha \ldots\ldots\ldots\ldots\ldots.. (3)$$

where

M_{tot} = mass of the fully occupied vehicle, in kg;

α = angle between the vehicle and the structure.

But in any case, the value for the calculation shall be not less than

$$F= 9.81\times M_{tot}\times 0.3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Alternatively, dynamic analysis can be performed.

Where collision is not intended to be part of the ride design or purpose collision shall be assumed to be an accidental action.

5.4 Seismic Forces

Seismic forces need only be considered by special request; they do not need to be combined with wind load cases. Seismic forces shall be applied in accordance with IS 1893 (Part 4).

5.5 Applicable Coefficients

Applicable coefficients for impacts, the vibration of structural components directly travelled over and collisions shall be considered.

5.5.1 *Impacts*

If impact forces are likely to arise in the structure or their individual parts during the travel motion (for example from the rail joints or from abrasive wear), then the moving loads under consideration (dead load and imposed load), shall be multiplied by an impact factor of not less than ϕ_1 =1.2, unless the type of structure demands an even higher value. If substantially greater impact forces (for example, due to rail joints) are ascertained during trial runs on the completed structures, and if these impact forces cannot be reduced to their design value by construction, then the impact factor shall be increased accordingly in a revised calculation.

Forces arising from start-up and braking, for example, in the case of hydraulic cylinders, are not considered to be impact forces (but normally imposed loads); *see* also **5.3.2** in this respect.

5.5.2 *Vibration of Structural Track Components*

In general, as a result of the vibration response of structural track components, for example, the track of a roller coaster, all resultant stresses shall be multiplied by the vibration coefficient ϕ_2 =1.2.

5.6 Structural Analysis — Principles

5.6.1 *General*

The limit states resulting from all different actions shall be determined separately for the individual actions given in **5**. It shall be verified that no relevant limit state exceeds the design properties. The limit states due to the combinations of actions shall be calculated. It shall be verified that the design value of internal forces or moments does not exceed the corresponding design resistance of the respective part and that the ultimate and serviceability limit states are not exceeded. For tests *see* **4.2**. Special consideration shall be given to the limit state verification regarding deformation and stability for structures, where the deformation limit can be a decisive value. Any favourable effect using methods of the theory of 2nd order may be taken into account (Second order analysis takes into account how the structure deforms while loads are being applied on it).

All verifications shall be performed for the most unfavourable loading. In this respect, the permanent, variable, and accidental actions, as well as the dynamic (inertia) forces, shall always be assumed to have the position and magnitude which result in the most unfavourable limit states for the structural and mechanical components to be analyzed. For structural, mechanical components, and items of equipment that are not permanent fixtures, it shall also be ascertained as to whether more unfavourable conditions are likely to arise when such items are displaced or removed.

Non-standard formulae shall be recorded in writing with the symbols in accordance with IS standards or to accepted standards. The sources of such formulae shall be stated if this source is publicly available. In other cases, the derivations of the formulae shall be presented to such an extent that their validity can be verified.

If computer processing for calculation is used, special consideration shall be given to the requirements for the review of computer calculations during the design approval. Clear information concerning the software, formulae, units, etc. shall be submitted. Input and output data of importance for design shall be printed in their entirety. The review of such calculations shall be performed by independent parallel calculations and/or independent software. The correctness of the assumptions regarding the input and the output data shall be comprehensively reviewed during design approval.

Design resistance, R_d, shall be evaluated in accordance with Formula (5).

$$R_d = R_k / \gamma_M \text{ ....} (5)$$

where

R_k is the characteristic value of the resistance (for example, material property);

γ_M = 1.10 is the partial safety factor of the resistance in static load combinations (for example, material property);

γ_{Mf} is the partial safety factor of the resistance in fatigue load combinations (*see* Table 4, for example, material property); and

γ_{Ma} = 1.0 is the partial safety factor of the resistance (for example, material property) in accidental combinations.

For materials other than steel the values for γ_M may be taken from IS 800.

5.6.2 *Analysis Principles for Various Types of Devices*

5.6.2.1 Conditions for calculating rotating type devices Amusement rides and devices shall be calculated in operative, inoperative, fully loaded, partially loaded, and unbalanced conditions.

One-sided loading shall be assumed as meaning that only those seats which are situated on 1/4 or 3/4 of the perimeter are occupied. The verification of the ultimate limit state shall be carried out for these one-sided loading conditions.

The overturning moment caused by one-sided loading when seats on at least 1/6th of the perimeter are occupied shall not exceed the stability moment in existence at that time, without taking the anchor ties into consideration. For this one-sided loading, the fatigue strength shall be verified. This shall be done also for a one-sided loading on 5/6th of the perimeter. The corresponding sector portions shall be selected for the most unfavorable case, and the seats situated at the edge of the sector concerned shall be included in the count.

An analogous procedure shall be adopted for multi-seated gondolas in lieu of single seats. If there are 18 or more seats uniformly distributed around the perimeter, a higher one-sided loading may be the determining factor in respect of adequate safety against overturning in certain cases. In this regard, it shall be assumed that the ratio between $M_{Rk,stb}$ (stabilizing moment) and $M_{Ek,dst}$ (overturning destabilizing moment) takes into account the partial safety factors according to Table 2.

If a device is also intended by design to rotate in reverse, then both directions of travel shall be taken into consideration when dimensioning the components of the device.

5.6.2.2 *Design and analysis principles for passenger-carrying units*

The seats and gondolas shall be sized by taking into account the forces resulting from dead loads, imposed loads, and motion. If seats are mounted on pin joints, they shall be arranged in such a way that no constraints can arise. The fastening of the seats onto outriggers shall also be designed for these forces. The arm rests, back rests, safety straps, chains, ropes, and associated locking devices shall be capable of absorbing the aforementioned forces arising from the passenger load. The structure of seats and gondolas shall be designed and analyzed in such a way that the forces arising (such as start-up and braking forces, impact forces, out-of-balance forces, and forces exerted from the passengers onto restraints and railings) are securely transmitted into the structure and fatigue problems are excluded.

5.6.2.3 *Roundabouts with several motions*

a) General

For roundabouts, in which the moving parts are rotated about several axes in different planes, all the forces which arise shall be determined. This shall be done by considering, as a minimum, the angular velocities, centrifugal forces, Coriolis forces due to the change of direction of one or more of the rotational axes, gyroscopic forces, starting and braking forces, and any impact forces which may arise.

b) Roundabout with planar motion only

Where the roundabout undergoes planar motion with constant speed rotation about two parallel axes only, the absolute velocities and accelerations (taking into account the relative motions and Coriolis' accelerations) may be calculated.

c) Roundabouts with outriggers running on rail tracks:

1) Roundabouts with arms centrally guided

With the internal or external location of the drive unit. On such roundabouts, due attention shall be paid to possible constraints and the bending and torsion moments in the arms that arise from the type of attachment of the gondolas or seats. The rails or running track shall be sized in such a way that the deflection due to wheel load does not exceed 1/500 of the span between track supports.

2) Roundabouts without a central guide

Safety against overturning of the cars shall be ensured by banking off the rails or by safety rollers and the like, or if necessary, by both these precautions. In the first step, the calculation of the safety against overturning of the substructure with a total partial safety factor of at least $\gamma = 1.0$, the anchorage in the foundation soil shall not be taken into consideration. In order to attain safety against overturning with partial safety factors in accordance with **5.7.1**, the anchorage may be taken into consideration in the calculation.

3) Roundabouts with an undulating track

On these installations, the inertial forces arising from the movement in space of the gondolas shall be taken into consideration.

4) Roundabouts with several rotation gears

On these installations, particular attention shall be paid to the effects of the Coriolis and Gyration forces on the structure.

In the case of rotary motions which are not positively actuated (i.e. free spinning and or passenger actuated), the effects of the individual rotation gears shall be investigated. For boom-type roundabouts (for example, round-ups, twisters, hully-gullies), the gondolas of which may be raised, the effects of the forces arising during vertical movement, starting up and braking shall be taken into account, with due consideration for any unfavorable effects of impact forces and centrifugal forces.

In this context, the effects of the above-mentioned forces on each outrigger, on the complete roundabout, and on the safety against overturning of the roundabout shall be investigated for the most unfavorable position in each case under static load combinations. Fatigue calculations in accordance with **5.9.3** shall be carried out. The telescopic jacks shall be supported without constraint and shall be sized adequately to withstand buckling.

The same applies, if appropriate, to lift roundabouts. Unavoidable accelerations on the telescopic jack at the beginning and at the end of a lifting stroke shall be taken into consideration by making a suitable allowance for increased loading when the roundabout components are being sized unless these accelerations are attenuated with damping elements.

If the pressure lines of the lifting cylinders fail, the lowering speed shall not exceed twice the normal operational lowering speed and in any case no more than 1.0 m/s, subjected to the requirements of **5.3.2.7**.

5.6.2.4 *Roller coasters with rail track-bound vehicles*

a) General (dynamics)

The longitudinal gradient of the rail shall be limited in such a way that the resultant force at angles perpendicular to it does not fall below 0.2 g. This value also applies to the passenger unit with the highest speed in the case of trains. If the resultant force should fall below the above value, the passengers shall be secured against lift-off in accordance with **8.1**.

The maximum transverse inclination of the rail, at the spots at which the car is likely to come to a full stop for operational reasons (for example, at safety brakes), shall be limited to a maximum value of 25° unless the design of the passenger containment system and the analysis of the biomechanical effect allow for a higher value. The path of the rail track shall be designed in such a way, that the instantaneous theoretical step in acceleration is limited to 2g. This is related to the center of mass and does not exclude the necessity for other calculations to be made for accelerations on passengers' bodies. The velocity, accelerations, and forces can be determined for the center of mass. Where there are multiple coupled cars the overall center of mass may be used.

A simulation of the motion over time shall be carried out in order to determine speed, accelerations, and forces.

Because the friction coefficients are liable to considerable variations in magnitude as a result of the running in time, the design, the surface finish of the rail, and the weather, it will be necessary to carry out a measurement of the actual velocity and accelerations. The data of the measurement shall be within the limit of design.

To determine the individual wheel forces additional calculations will be necessary.

For high speed tracks having tight loops or helices, the need for rigid body dynamics shall be considered.

b) Supporting framework

If the calculation is based on a continuous rail track above the support columns, a column settlement by virtue of the reduction by 50 % of the moment at support, and a column heightening by virtue of the increase by 25 % of the moment at support shall be assumed. The increase or reduction of these moments need not be taken into consideration for the verification of fatigue in view of the low numbers of cycles anticipated.

For exposed support columns without cladding anchored by the continuous rail in the overall structure, the assessment of the wind load may be ignored for the verification of the stability and of the safety against sliding.

The safety of the installation against overturning, when it is subjected to wind load need not be verified as a general rule, unless exceptionally large horizontal forces are likely to arise, as a result of a particularly unfavourable shape, exceptionally large wind load areas of the framework components (decorations, lighting strips), or as a result of the partial or total cladding of the framework or track.

c) Passenger units

All forces arising in the chassis and superstructures shall be followed in the calculation from their point of origin, down to the supports. Thus, for example, in the case of passenger units with one oscillating and one rigid axle, the moments from forces transverse to the car above the oscillating axle, can only be absorbed by the rigid axle.

Forces transverse to the car, for example, can only be transmitted through wheels that run against the side of the rail.

If the load wheels are not designed in such a way that they are also capable of absorbing lateral forces, then special guide rollers shall be provided for this purpose.

The vehicles shall be equipped with devices for the prevention of derailment and lift-off. Safety devices against lift-off (rollers or claws) shall in any case be calculated for the actual forces acting on them. As a minimum, they shall be sized for 50 % of the fully-loaded vehicle weight, even when there is no lift-off.

d) Brakes

Each stopping or speed regulation brake (at the end of the descent, stopping after each journey) shall be designed in such a way that the braking deceleration does not exceed a maximum value of 5.0 m/s^2. Greater deceleration is permitted on condition that special devices for the protection (lap bars, etc.) of the passenger are provided; *see* **8**.

Safety brakes shall be arranged for the planned minimum distance between successive cars or trains in such a way that there will always be sufficient braking elements between any two cars or trains to prevent a collision.

Each safety brake shall be designed in such a way that the braking deceleration does not exceed a maximum value of 7.0 m/s^2, unless a greater deceleration is permitted in which case special devices for the protection (lap bars, etc.) of the passenger shall be provided; *see* **8**.

Fatigue need not be considered for safety brakes, which are only operated in emergency cases. The maximum deceleration shall be assessed by using the highest attainable friction coefficient for the selected brake surface materials with the minimum load.

With regard to the sizing of the effective deceleration length, it shall be assumed that the car is still able to come to a full stop, when applying a safety factor of 1.2 (related to the friction coefficient), to the minimum friction coefficient experienced due to weather influences, wear, maximum speed and load. The limiting values shall be checked on the finished installation. During such tests, the minimum friction and maximum speed shall be produced as far as is possible using wet rails, wet brake elements, and wet fins.

Speed regulation brakes shall be calculated by using fatigue load cases.

5.6.2.5 *Anti-rollback devices*

Installations, on which the cars or trains are conveyed on the ascent ramp by means of chains, ropes, friction wheels, or by self-propulsion, shall be provided with either safety devices to prevent running back, or with automatically acting brakes to prevent running back.

If it is planned that several cars or trains are to be present at the same time on the section of track situated between the end of the lift or ascent ramp and the station, or the brake situated before the station, then safety devices to prevent running back shall also be fitted in the uphill sections of the track after the valleys.

However, if a passenger unit or train is intended to be able to travel backward along with the track and through the station then safety devices against running back can be omitted from the ascent ramps.

Moreover, if there are several cars or trains on the track, safety devices against running back on the uphill sections may be dispensed with, on condition that the individual track sections are safeguarded by a fail-safe block-zone system, with automatically controlled brakes.

If by design, it is intended that there is to be only a single car or a single train on the track at any one time, safety devices against running back can be omitted from the uphill stretches after the valleys or when the car is intended to roll backward. The fatigue strength need not be verified for the anti-rollback devices. If the car is stopped by the anti-roll back device with a sudden impact then an impact factor shall be assumed for dimensioning purposes. This value shall be at least one-half of the vertical maximum running back height [*h* in centimeters (cm)] if no exact verification is carried out, and in any case, shall not be less than 2.0. A load of $\phi \times Q$ shall be assumed for dimensioning purposes where Q is defined as the dead load of the car plus the live load of passengers (fully loaded roller coaster car).

$\phi \geq 0.5 \times h$

ϕ shall not be less than 2

The two conditions above shall be satisfied.

If the deflection is known or can be determined reliably, the following formula shall be applied:

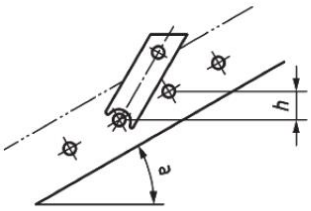
$$\phi \geq 1+\sqrt{1+\frac{2h}{\delta_0 \sin\alpha}}$$

where

δ_0 = total deflection of centre of mass along slope;

α = slope angle (see Fig 1);

h = height (see Fig 1).



Key

α slope angle

h height

FIG. 1 IMPACT FACTOR/RUNNING BACK ELEVATION

Measured data and/or dynamic analysis can be used to determine impact loads also.

5.7 Verification of Stability

5.7.1 *General*

Proof shall be provided of safety against overturning **5.7.2**, sliding **5.7.3**, and lifting **5.7.4** of amusement devices and their components. Favourably acting imposed loads and dead loads of components and accessories which are not always present shall not be taken into account, when providing proof of safety against overturning, sliding, and lifting. Only the lowest value of continuously acting favourable influences including material variations (for example, G_{sup}, G_{inf}) shall be taken into account. For foundations, a national standard or an internationally accepted standard shall be applied to the prevailing rules of this sub-clause. A frost-free foundation for amusement devices is only required in cases where lifting or lowering/settling due to frost could lead to damage or failure. Only the lowest value of continuously acting favourable influences shall be taken into account. If an adequate degree of safety cannot be achieved by virtue of a dead load of a structure alone, then further additional steps shall be taken to ensure it, such as counterweights, anchors, and buttresses. As the weight of amusement devices may be determined and verified accurately this allows a more precise determination of the safety factors to be made (*see* Table 2).

Table 2 Safety Factor Against Overturning, Sliding, and Lifting

(*Clauses* 5.6.2.1, 5.7.1, 5.7.3, 5.7.8, 5.8.1)

Sl. No.	**Loading**	γ
(1)	(2)	(3)
i)	Favorably acting proportions of the dead load	1.0
ii)	Unfavourably acting proportions of the dead load	1.1
iii)	Unfavourably acting wind loads	1.2
iv)	Accidental combinations	1.0
v)	Unfavorably acting proportions of loads other than the loads listed in items **2**, **3** and **4**	1.3

a. If loads are resolved into components, then these components shall be multiplied by the same value of γ.

b. For devices higher than 20 m, $\gamma = 1.2$ shall be replaced by $\gamma = 1.2 + 0.3 \times (h\text{-}20)/40$ where h is the total height of device in metres

5.7.2 *Overturning*

The safety against overturning shall be calculated from:

$$\sum \gamma M_{\mathrm{Rk,stb}} \geq \sum \gamma M_{\mathrm{Ek,dst}}$$

where

γ = partial safety factors in accordance with Table 2;

$M_{\mathrm{Rk,stb}}$= stabilizing moment proportions;

$M_{\mathrm{Ek,dst}}$= overturning destabilizing moment proportions.

Care shall be taken to ensure that the loads entered in the calculation can be accommodated by the shear stiffness of the structure.

5.7.3 *Sliding*

The safety against sliding shall be calculated from :

$$\mu \sum \gamma N_{\mathrm{k}} \cdot \geq \sum \gamma H_{\mathrm{k}}$$

where

γ = partial safety factors in accordance with Table 2;

N_{k}= vertical load components;

H_{k}= horizontal load components;

μ = coefficient of friction in accordance with Table 3.

The coefficients of friction in Table 3 may be assumed for the determination of the frictional forces, unless higher values determined by tests are available in individual cases, or unless the effect of moisture requires the adoption of lower values.

Table 3 Coefficient of Friction μ

(Clause 5.7.3)

Sl. No. (1)	Material (2)	Wood (3)	Steel (4)	Concrete (5)
i)	Wood	0.40	0.4	0.6
ii)	Steel	0.4	0.1	0.2
iii)	Concrete	0.6	0.2	0.5
iv)	Clay	0.25	0.2	0.25
v)	Loam	0.4	0.2	0.4
vi)	Sand and gravel	0.65	0.2	0.65

It shall be borne in mind that loosening by vibration may occur in the case of supports subjected to vibrating stress.

If stability is not obtained by static friction alone, then the structure shall be anchored in the ground. In such cases, the safety against sliding shall be calculated in conjunction with the action of soil anchors. Under these conditions, the coefficients of friction in accordance with Table 2 shall only be entered in the calculation at 70 % of the listed values.

$$\bar{\mu} \cdot \sum \gamma N_{\mathrm{k}} + Z_{\mathrm{h,d}} \geq \sum \gamma H_{\mathrm{k}}$$

where

$\bar{\mu}$ = 0.7 μ and μ is the coefficient of friction in accordance with Table 3.

$Z_{\mathrm{h,d}}$ = horizontal design load-bearing capacity of the anchor (*see* **5.8**).

5.7.4 *Lifting*

The safety against lifting shall be calculated from

$$\sum \gamma N_{\mathrm{Rk,stb}} \geq \sum \gamma N_{\mathrm{Ek,dst}}$$

where

γ = partial safety factor in accordance with Table 2;

$N_{\mathrm{Rk,stb}}$ = vertical stabilizing load components;

$N_{\mathrm{Ek,dst}}$ = vertical lifting destabilizing load components.

With anchor ties the following relationship shall be applied:

$$\sum \gamma N_{\mathrm{Rk,stb}} + Z_{\mathrm{vd}} \geq \sum \gamma N_{\mathrm{Ed,dst}}$$

where

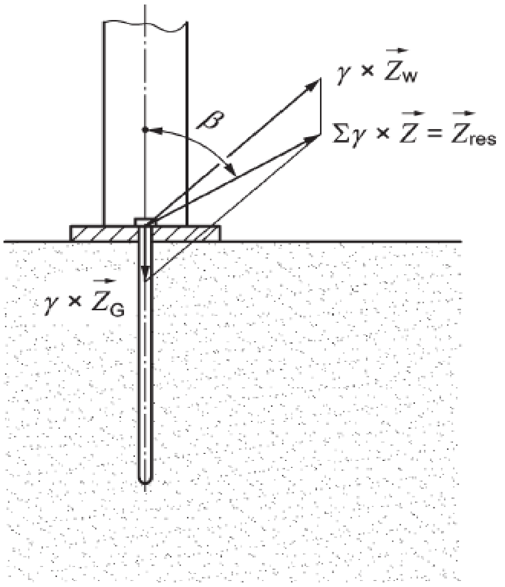
$Z_{\mathrm{v,d}}$ = vertical design load-bearing capacity of the anchor (*see* **5.8**).

5.8 Ground Anchorage

5.8.1 *Calculation of Loads on Anchors*

The resulting load Z_{res} acting on the anchorage shall be determined by vector summation, taking into account the partial safety factors shown in Table 2. This load Z_{res} shall be

$$Z_{\mathrm{res}} = \sum \gamma Z \leq Z_{\mathrm{d}}$$


$\gamma \times \vec{Z}_W$
$\Sigma\gamma \times \vec{Z} = \vec{Z}_{res}$
β
$\gamma \times \vec{Z}_G$

Key

Z_G	favourably acting resultant of permanent actions
Z_W	unfavourably acting portion of variable actions
γ	safety factor in accordance with Table 2
β	angle of acting tensile force to the vertical

FIG 2 ANCHOR LOADING

5.9 Verification of Strength

5.9.1 *General*

A distinction shall be made between predominantly static stress and predominantly fluctuating stress. Fluctuating stress occurs both in the form of pulsating stress (stress which fluctuates within two limiting values without any change of sign, [$\Delta\sigma$ = minσ /maxσ]) and in the form of alternating stress (stress which fluctuates between two limiting values and changes its sign). For both situations the stress range $\Delta\sigma$ = maxσ - minσ is significant for the calculation.

Fatigue calculation of welded structural items shall be performed to relevant standards which are based either on the stress range $\delta\sigma$ concept or in minσ/maxσ stress concept, if the minimum lifetime requirements in **5.9.3.1 (c)** are applied and a partial safety factor according to Table 4 at 95 % survival probability or equivalent is maintained.

The resistance of notch details shall be determined as a statistical value with 95 % of survival probability and a confidence interval of 75 %.

The minimum lifetime requirements in **5.9.3.1(c)** with at least the partial safety factors of Table 4 shall be considered.

Structures subjected to fluctuating stress which is likely to be exposed to more than n = 10^4 stress cycles during their expected service life shall be dimensioned by calculation of fatigue strength.

The complete analysis of a device shall be based on a clearly specified and internationally accepted standard.

5.9.2 *Predominantly Static Stress*

Permissible stresses of materials used for structural components shall be taken from the selection of materials.

With regard to general stress analysis of machinery components made of steel, including components that act simultaneously as structural components, the following relationships shall apply:

$$R_d \leq R_{eH}/\gamma_{M0}$$

and

$$R_d \leq R_m/\gamma_{M2}$$

where

R_d is the design material resistance;

R_{eH} is the yield strength;

R_m is the ultimate strength;

γ_{M0} = 1.1 is the partial safety factor for elastic strength resistance (yield);

γ_{M2} = 1.5 is the partial safety factor for ultimate strength resistance when $R_{eH}/R_m <$ 0,75;

γ_{M2} = 2.0 is the partial safety factor for ultimate strength resistance when $R_{eH}/R_m >$ 0,75.

The smaller of the two values R_d above shall be used.

5.9.3 *Fluctuating Stress*

5.9.3.1 *Fatigue assessment of structural components*

An assessment of fatigue life as a result of repeated fluctuation of stress shall be carried out.

a) Partial safety factors for fatigue

For fatigue loads, a partial safety factor shall be applied: γ_{Ff} = 1.0

The following values for the partial safety factors for steel shall be applied:

Table 4 Partial Safety Factor for Fatigue Resistance in Stress Range Concept

(*Clauses* 5.6.1 *and* 5.9.1)

Sl. No.	**Examination and access**	**Rupture will not affect the collapse**	**Rupture will affect the collapse**
(1)	(2)	(3)	(4)
i)	Structural part accessible during regular thorough examination	γ_{Mf} = 1.0	γ_{Mf} = 1.1
ii)	Structural part not accessible during regular thorough examination	γ_{Mf} = 1.05	γ_{Mf} = 1.15

b) Fatigue loads

When calculating Δσ or Δτ, the influence of dead loads which do not change in position, the components of variable actions which do not vary in time and position, snow loads, temperature loads, loads due to assembly and wind loads (without induced oscillation) need not be considered. In the case where wind loads induce oscillation, the wind pressure can be set to 50 % of the values in Table 1, column 2, if there is no other calculated critical value of the wind pressure due to the wind speed, at the natural frequency. An investigation of wind-induced oscillation shall be performed to evaluate additional fatigue loads.

When calculating Δσ or Δτ, the following actions shall be taken in account as a minimum:

1) Dead loads with change of position;
2) Moving imposed loads;
3) Driving and braking forces according to **5.3.2**;

4) Load coefficients for impact and vibrations of parts directly travelled over;
5) Intentional collision forces;
6) Inertia forces;
7) Centrifugal and Coriolis force;
8) Gyroscopic effect.

Where there is a movement of dead loads, when assessing $\Delta\sigma$ or $\Delta\tau$ (for example, for lifted booms), the maximum and minimum stresses shall be calculated including dead loads:

$\Delta\sigma = \sigma_{max} - \sigma_{min}$

$\Delta\tau = \tau_{max} - \tau_{min}$

c) Number of load cycles

The fatigue assessment of load-bearing parts shall consider the following number of load cycles if no more precise calculation about load cycles and a lifetime can be provided.

Fatigue limit at 35 000 h:

At least 35 000 operating hours shall be assumed in the fatigue calculation of amusement devices not including loading and unloading time. The number of load cycles shall be determined for each specific amusement device and its components.

Endurance limit:

Safety-related components shall be designed for endurance limits. In this context, the stress range $\Delta\sigma_D$ is understood to be the constant amplitude fatigue limit. When no stress range is higher than $\Delta\sigma_D$ for the respective detail category, infinite fatigue life can be assumed. If no detailed calculation of the load cycles will be provided endurance limit life calculation shall be used.

Standard products:

Mass-produced replaceable safety-related machinery components used as structural parts (for example, bearings and slewing rings) for which company standards are available are excluded. These shall be dimensioned for at least 5 000 operating hours. The replacement frequency of components shall be based on the calculated lifetime in hours or number of cycles. A theoretical lifetime calculation shall be submitted.

d) Fatigue assessment of machine components (welded and non-welded)

Machine components are, for example, axles, pins, shafts, wheel bogies, coupling bars, restraint bars, etc. Assessment of welded parts may also follow the procedure given in **5.9.3.1** or IS 800 (Section 3).

The following described principle of assessments can be adopted to non-welded parts. Fatigue assessment is requested for parts with more than 10 000 load cycles.

e) Fatigue resistance

The fatigue resistance shall take into account:

1) Material strength
2) Construction parameters
3) Size effects
4) Shape effects
5) Corrosion influence
6) Surface influence
7) Alternate strength
8) Endurance limit strength
9) Service strength

The strength values shall consider notch case and stress ratio.

The resistances shall comply with a 97.5 % probability of survival.

f) Fatigue stress

Nominal stress or local stress shall be used for fatigue assessment. Stresses shall be determined in accordance with the general principles of stress analysis.

The nominal stress method can be used for beam-like systems. Nominal stresses σ, τ shall be investigated.

Local stress method on base of Finite Element Analysis is possible for shell or volume investigations. Main stresses σ_1, σ_2, σ_3 shall be investigated. Main stress σ_1, σ_2 shall be orientated on the surface, σ_3 perpendicular to the surface.

5.9.4 *Bolts*

Bolts conforming to IS 1368 shall be used.

5.9.5 *Ropes & Chain*

Ropes & Chains conforming to IS 2266 & IS 3109 (Part 1) shall be used.

6 REQUIREMENTS FOR DESIGN AND MANUFACTURE OF RIDES

6.1 Moving Walkways, Travelators and Similar

The belt of moving walkways or travelators shall be either seamless or have not more than one joint which shall not protrude.

A handrail, intermediate rail, and toe board according to **6.1.1** shall be provided on both sides of moving walkways or conveyor belts. A railing on only one side is allowed if the moving walkway or conveyor belt is used for access to or egress from passenger units. The maximum clearance between the belt and the toe board shall not exceed 4 mm.

The slope of a moving walkway or travelator shall not exceed 1 in 6 unless moving handrails are provided, in which case the slope shall not exceed 1 in 4.

In case of perpendicular egress from the moving walkway or travelator, the end of the moving walkway shall be guarded with a final handrail and an intermediate rail at 45° with respect to the direction of motion. Additionally, a trip board, or equivalent system, which can interrupt the power in case a passenger is pushed against the final handrail, shall be provided. The access to such a moving walkway shall be controlled by automatic or manual means to avoid danger due to congestion. An emergency stop button shall be fitted at both ends.

Provision shall be made to protect the end of moving walkways or travelators to prevent trapping or pinching. The end return and tension rollers shall be suitably protected. If, because of the type of surface, such protection is not possible, perpendicular egress, according to the above clause shall be provided.

The maximum relative speed shall not exceed 0.75 m/s with parallel egress from the stationary platform and 0.5 m/s with perpendicular egress. If the walkway or travelator is used as part of the attraction itself then higher speeds may be accepted. *See* Fig 3.

Effective brakes shall stop and hold the walkway in case of any interruption of the power supply.

The minimum width of the travelator shall not be less than 0.60 m.

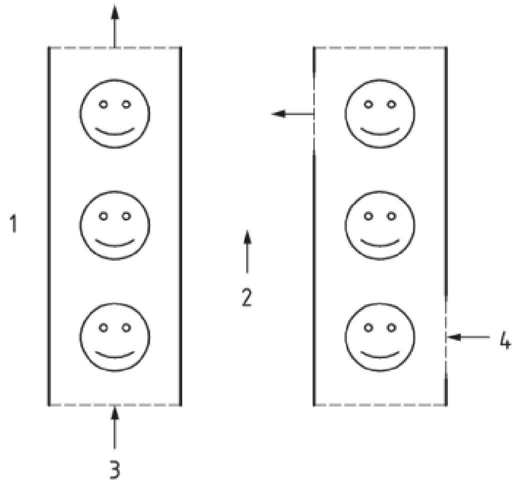


FIG. 3 TRAVELATOR DIRECTION IN RELATION TO PASSENGER ACCESS/EGRESS

where,

1 Boundary of travelator;
2 Direction of travelator;
3 Example of arrow depicting parallel access/egress from travelator;
4 Example of arrow depicting perpendicular access/egress from travelator.

6.1.1 Protection against falls from one level to another by railings or fencing

a) General

Fencing, railings, or other suitable means shall be provided where a person might fall 0.40 m or more due to a difference in the height of adjacent levels. Fences for this purpose are specified. Railings shall as a minimum consist of two guard rails (a top rail and an intermediate rail) In addition, where the fall height is more than 1.0 m a toe board of 100 mm height shall be fitted in order to protect people passing underneath.

Fences and railings shall be constructed in accordance with IS 4912 with regard to entrapment.

Fences or other suitable means are required to prevent falls from a height of 2 m or more where the public has access.

Where there is a low probability of serious injury (not giving direct access to moving machinery, nor falling from heights of more than 2 m) decorative fences are also allowed. In this case chains and ropes for the top and intermediate rails are also permitted, if they withstand the forces defined in **5.3.1.2** with a maximum deflection of 30 mm. Not tensioned chains, ropes, or other non-rigid materials are not permitted.

Where there is a difference in levels up to 0.60 m the risk assessment should determine if any area separation system is required.

b) Handrail height Handrails shall have free space around them of 38 mm and the grip shall be in accordance with IS 4912.

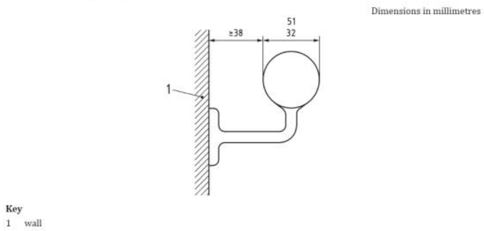


FIG. 4 GENERAL HANDRAIL CLEARANCES

c) Classification of area separation systems

Area separation systems are classified as follows:

*J*₁ — predominantly visual area separation systems: colored stripes on the floor or fixed steps, poles, cones, or equivalent.

*J*₂ — physical area separation systems: flexible devices, such as ropes, chains, cords, etc., which need not withstand horizontal forces.

*J*₃ — physical area separation systems: rigid devices, such as fencing or railings which can withstand horizontal forces.

d) Classification of access and egress openings in fences and railings

The number of openings in fences and railings shall be limited to the number and width necessary for safe access and egress. Each opening shall not be more than 2.5 m wide. The access and egress openings are classified as follows:

K_1 — Openings without any direct control;

K_2 — Openings controlled by attendants;

K_3 — Openings provided with barriers or gates indicating the access to a restricted zone by limiting the flow of persons, (for example, mechanical gates, turnstiles, etc.);

K_4 — Openings provided with barriers or gates where the locking and unlocking are actuated by the operator or attendant;

K_5 — Openings provided with barriers or gates, the closed state of which, enables the ride to start and the open state of which causes the ride to stop.

For each defined category of rides, or for each group or single ride being in the same ride category and having the same specific features, the minimum requirements for access and egress openings will be expressed by the above classification.

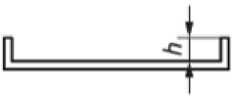
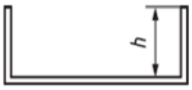
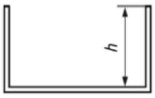
7 MINIMUM DIMENSIONS OF THE SAFETY ENVELOPE

To prevent passengers from being injured by stationary or moving objects or objects belonging to passenger units other than that in which they are located, and in the absence of other measures reducing the reach of the passengers, the following minimum general safety distances shall be provided:

a) The minimum lateral safety distance min. y_{lat} relates to speed and height of the seat sides, *see* Table 5.
b) 200 m (respectively 1.70 m for children up to the age of 10 years) above the floor of the passenger units (*see* Fig. 5);
c) 1.50 m above the seat (respectively 1.30 m for children up to the age of 10 years) if the passenger is positively restrained from standing up (*see* Fig. 6).
d) 1.0 m (respectively 0.9 m for children up to the age of 10 years) below the seat in suspended seats (*see* Fig. 7)

Table 5 Minimum Lateral Safety Distances In Relation to Side Height of the Seat, from Inside Part of the Seat and If No other Hazards (Min. Y_{lat})

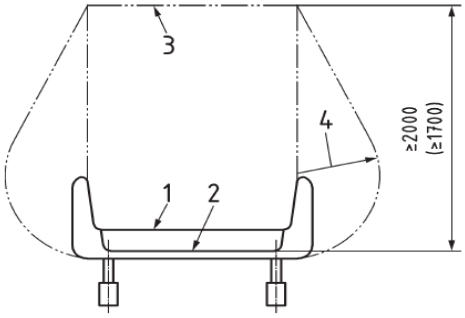
(*Clause* 7 (a))

Sl. No.	Cat.	Speed, v $\frac{m}{s}$	$h \leq 400\ mm$ 	$400 < h \leq 600\ mm$ 	$h > 600$ mm 
(1)	(2)	(3)	(4)	(5)	(6)
i.	A	$v<3$	700 mm	500 mm	300 mm
ii.	B	$3<v<10$	900 mm	700 mm	500 mm
iii.	C	$10<v<20$	1 000 mm	900 mm	500 mm
iv.	D	$v>20$	1 000 mm	1 000 mm	700 mm

If an over-shoulder restraint is used and the lateral movement of the upper body is limited the min. y_{lat} values similar to a side height of $h>$ 600 mm may be used. If the reach envelope is limited by other installations (for example, cabin) then even fewer min. y_{lat} values may be adopted.

Any special situation needs to be taken into consideration in the definition of the minimum safety distances. Safety distances may be extended due to accelerations, darkness, sharp-edged elements, or vice versa.

Dimensions in millimetres



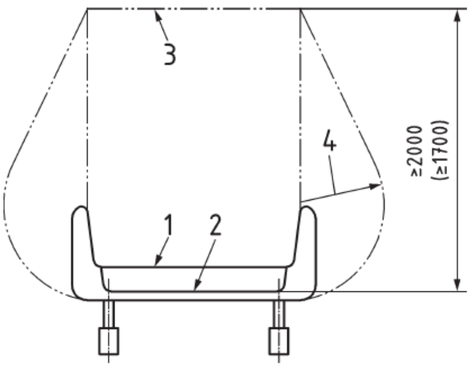
Key

1 seat surface
2 floor surface
3 safety envelope
4 minimum lateral safety distance min. y_{lat}

NOTE Values for children up to the age of 10 years are given in parentheses.

FIG. 5 VERTICAL SAFETY DISTANCE FROM FLOOR AND LATERAL SAFETY DISTANCE

Dimensions in millimetres



Key

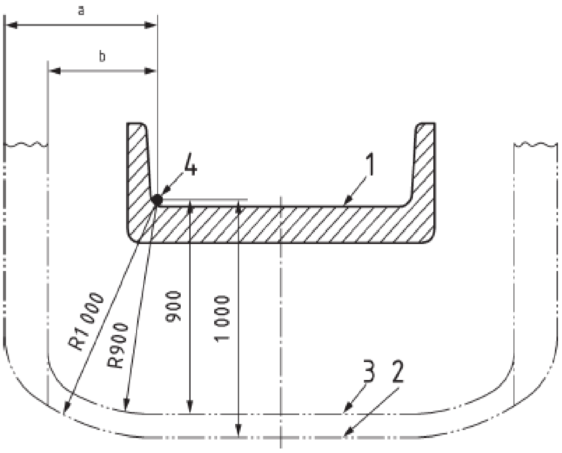
1	seat surface
2	floor surface
3	safety envelope
4	minimum lateral safety distance min. y_{lat}

NOTE Values for children up to the age of 10 years are given in parentheses.

FIG. 6 VERTICAL SAFETY DISTANCE FROM SEAT AND LATERAL SAFETY

If passenger units are free-ranging and controlled by the passenger, the distance in **7** applies only to fixed objects.

Dimensions in millimetres



Key

1	seat surface
2	safety envelope
3	safety envelope for children up to the age of 10 years
4	corner centre radius
a	Minimum lateral safety distance min. y_{lat}.
b	Minimum lateral safety distance min. y_{lat} for children up to age of 10 years.

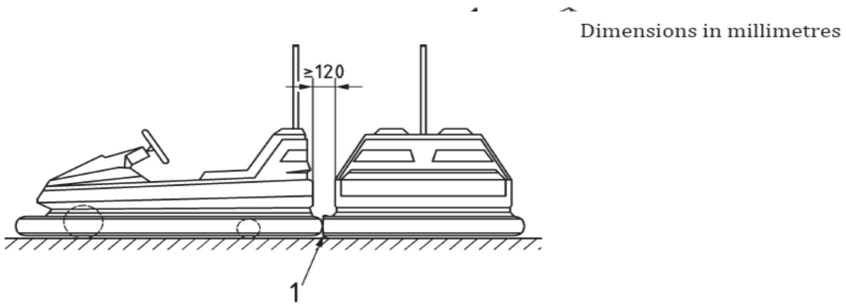
FIG. 7 MINIMUM SAFETY DISTANCE FOR LEGS IN SUSPENDED SEATS

7.1 Minimum Safety Distances between Passenger Containments

Additionally, the following distance shall be maintained: 120 mm from the outside of the unit to any other part at the seat's height of another unit in the most unfavourable operating condition (*See Fig*. 8). For dodgem/bumper cars see minimum safety distances in Table 7.

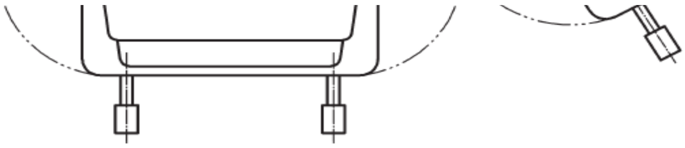
FIG. 8 SAFETY DISTANCE FOR FREE-RANGING VEHICLES

If the passenger units are not free-ranging, the safety envelopes shall not overlap (*see* Fig.9*)*.



Key

1 distance element



Key

1 safety envelope

2 minimum lateral safety distance, min. y_{lat}

FIG. 9 RELATIVE POSITION OF SAFETY ENVELOPES

8 RESTRAINT DEVICES LIMITING PASSENGER MOVEMENT

Passenger restraints and their locking devices shall be designed in such a manner as to prevent the trapping and crushing of body parts. Passenger restraint devices shall have a configuration such as not acting on sensitive and fragile parts of the passenger's body. Even if provided with warning lights and/or acoustic warnings they shall allow a visual and/or physical verification of their correct closing by the attendant. Powered passenger restraint devices may create additional hazards giving rise to injuries. Their movement shall be slow and the maximum exerted force shall not be more than 0.15 kN (0.08 kN if children are also admitted) measured on the active edge of the device. Locking and latching devices shall be designed in such a way as to prevent unlocking without deliberate and intentional action. Locking devices shall not lose their locking action in the case of malfunction or emergency stop of the ride unless it is safe to do so.

8.1 Passenger Restraints

Each element of the ride, designated to accommodate passengers (passenger unit), shall be provided with adequate means to restrain passengers within the device, and, if necessary, in their places, depending on the nature of the ride and the results of the DRA (Design Risk Assessment)This is a document that shall be produced by the designer of every device. The design risk assessment shall be used to guide the designer into making the correct decisions in the total design ethos (for example, material selection, PLC program, ergonomic characteristics, biomechanical effects, etc.) so that an acceptable level of risk resides (residual risk) from each design decision. Although not an operation and use risk assessment, the DRA shall be used to guide the structure and content of the operating and maintenance procedures**)**.

The design of restraint shall minimize by risk assessment at least the following risks for passengers:

a) Hitting parts in relative motion or being trapped in between them;
b) Being injured by contact with any part of the structure of the ride, including passenger restraint;
c) Being struck by parts of the structure in which they are carried;
d) Being hit by other passengers resulting from the type of motion induced by the ride.

The design of restraint shall avoid the ejecting and falling out of the passenger unit

In the case of malfunction or emergency stop, when the passengers are maintained in their places by the restraint devices, arrangements shall be made for unlocking the device by the authorized personnel, when it is safe to do so.

Passenger restraints shall be provided as determined by the designer based on risk assessment.

This determination shall be based on the passenger restraint and containment analysis performed in accordance with criteria defined in this standard and shall take into consideration the nature of the amusement ride or device and the intended adult or child passenger's physical characteristics.

The passenger restraint and containment analysis shall identify the need for a restraint system for reasons other than simply the acceleration or seat inclination. The analysis shall also evaluate the need for locking or latching functions when restraints are required.

The designer shall take into consideration the evacuation of passengers from any reasonably foreseeable position and/or situation on the ride or device, including emergency stops and stops in unplanned locations. The passenger restraint and containment analysis shall address whether individual or group restraints releases are appropriate.

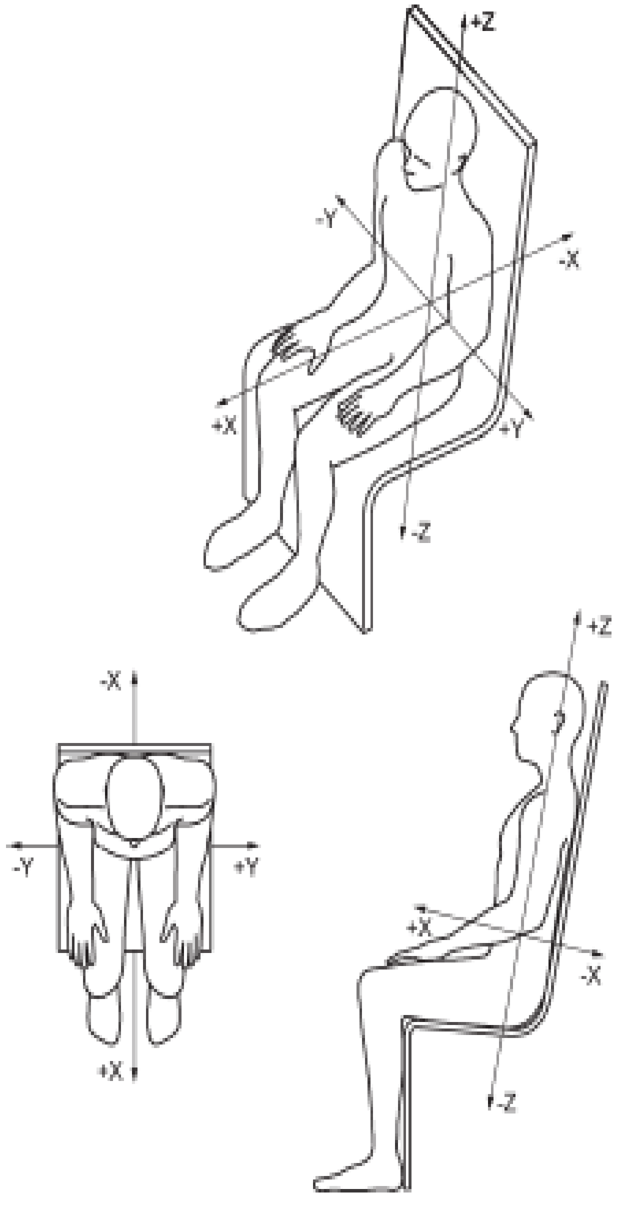
With DRA the designer specifies the state, locked or unlocked, of the restraint system in the event of unintended stop, for example, emergency stop or loss of power.

Restraint devices shall be provided in cases where it is reasonably foreseeable that passengers could be lifted or ejected from their seats or riding positions by the acceleration of the amusement ride or device, or by seat inclination, during the ride or device cycle and other reasonably foreseeable situations, for example, the application of emergency brakes or vehicles stopped in inverted positions.

The restraint diagram shown in Figure 11 shall be used as part of the passenger restraint and containment analysis for determining if restraint is required, and if required, what type. The restraint diagram identifies and graphically illustrates five distinct areas of theoretical acceleration.

Each of the five distinct areas may require a different class of restraint. The restraint diagram applies for sustained acceleration levels only. It is not to be applied for impact acceleration.

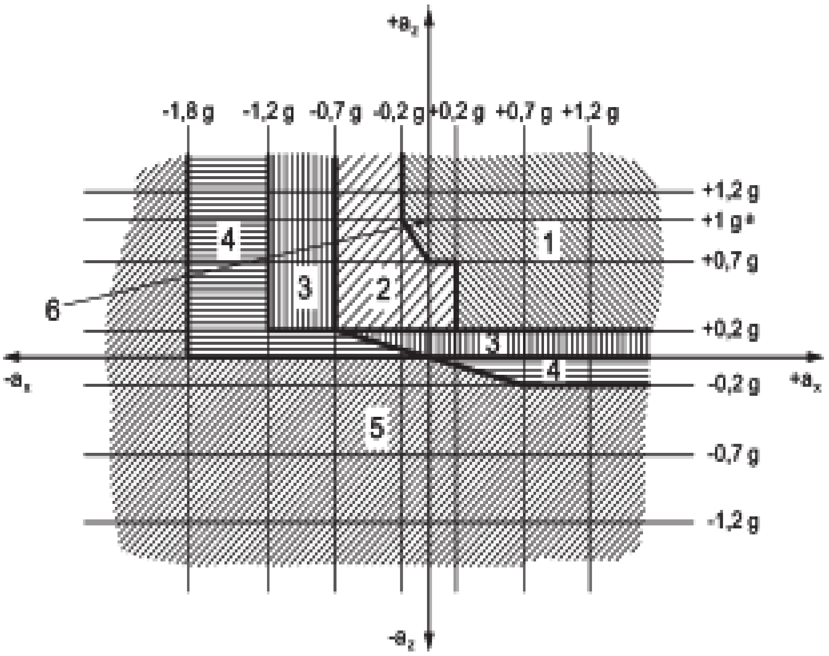
For the axis, convention refers to Fig. 10.



A positive acceleration is defined in accordance with following the coordinate system:

$+a_z$	presses the body into the seat downwards, described as "eyes down".
$-a_z$	lifts the body out of the seat, described as "eyes up".
$+a_y$	presses the body sideward to the right, described as "eyes right".
$-a_y$	presses the body sideward to the left, described as "eyes left".
$+a_x$	presses the body into the seat backward, described as "eyes back".
$-a_x$	pushes the body out of the seat forward, described as "eyes front".

FIG.10 BODY COORDINATE SYSTEM



Key

$+a_z$	downward into seat (eyes down)
$-a_z$	lift (eyes up)
$+a_x$	acceleration (eyes back)
$-a_x$	deceleration (eyes front)
1	Area 1
2	Area 2
3	Area 3
4	Area 4
5	Area 5
6	at rest
*	Normal gravity.

FIG. 11 RESTRAINT DIAGRAM

Area 1 — A Class 1 no restraint is required. Based solely on Area 1 dynamic forces, no restraint is required; however, other criteria in this practice (that is, the ride analysis) may require a higher-class restraint device.

Area 2 — A Class 2 restraint is required, unless passengers are provided sufficient support and the means to react to the forces, for example, handrails, footrest, or other devices, and if they cannot fall out, or be ejected from the compartment due to the acting forces.

Area 3 — A Class 3 restraint is required.

Area 4 — A Class 4 restraint is required.

Area 5 — A Class 5 restraint is required.

The application of the restraint diagram Fig.11 is intended as a guide. Any special situation needs to be taken into consideration in designing the restraint system, for example, the duration of the acceleration. In particular, where lateral accelerations higher than $a_y \geq \pm 0.5g$ occur, seats, backrests, and restraints shall be designed accordingly. Unexpected stopping positions of the passenger units shall also be considered (for example, upside down). Any intended unconventional seating or passenger body position may need special consideration. In Figure 21 no information on the absolute acceleration limits is given.

In boundary cases, the lower category of the restraint class may be chosen.

Fig. 11 is a design guide. If Fig. 11 is used to validate the choice of restraint by measurements then data shall be filtered to 1 Hz (only for application of this figure) and applying a tolerance of ± 0.05g.

The determination of the class of the restraint, based on Fig.11, is as follows.

8.2 Classification of Passenger Restraint Devices

Restraint devices have the following requirements based on their classification according to Fig. 11. *See* also Table 6.

Class 1: Unrestraint or no restraint at all.

Class 2: A latching restraint device for each individual passenger or a latching collective restraint device for more than one passenger. A Class 2 restraint device shall have at least the following:

a) Number of passengers per restraint device — The restraint device may be for an individual passenger or it may be a collective device for more than one passenger.

b) Final latching position relative to the passenger — The final latching position may be fixed or adjustable in relation to the passenger.

c) Type of latching — The passenger or operator may latch the restraint.

d) Type of unlatching — The passenger or operator may unlatch the restraint.

e) Restraint position monitoring — In addition to the operator responsibilities no independent restraint position monitoring is required.

f) Means of activation — The restraint may be manually or automatically (for example, motorized) opened and closed.

g) Redundancy of latching device — Redundancy is not required.

Class 3: A latching restraint device for each individual patron or a latching collective restraint device for more than one passenger. A Class 3 restraint device shall have at least the following:

a) Number of passengers per restraint device — The restraint device may be for an individual passenger or it may be a collective device for more than one passenger.

b) Final latching position relative to the passenger — The final latching position must be adjustable in relation to the passenger, for example, a bar or a rail with multiple latching positions.

c) Type of latching — The passenger or operator may manually latch the restraint or it may be automatically latched. The manufacturer shall provide instructions that the operator shall verify the restraint device is latched.

d) Type of unlatching — The passenger may manually unlatch or the operator may manually or automatically unlatch the restraint.

e) Restraint position monitoring — In addition to the operator responsibilities no independent restraint position monitoring is required. The design shall allow the operator to perform a visual or manual check of the restraint each ride cycle.

f) Means of activation — The restraint may be manually or automatically (for example, motorized) opened and closed.

g) Redundancy of latching device — Redundancy shall be provided for the latching device function.

h) Monitoring of latching device — The latching device shall be periodically tested prior to being put into operation with a guest. The frequency and procedure of such a periodic test shall be determined by the mechanical design.

Class 4: A redundant locking restraint device for each individual passenger. A Class 4 restraint device shall have at least the following:

a) Number of passengers per restraint device — A restraint device shall be provided for each individual passenger.

b) Final locking position relative to the passenger — The final locking position of the restraint shall be adjustable in relation to the passengers, for example, a bar or a rail with multiple positions.

c) Type of locking — The restraint device shall be automatically locked.

d) Type of unlocking — Only the operator shall manually or automatically unlock the restraint.

e) Restraint position monitoring — In addition to the operator responsibilities an independent restraint position monitoring system shall initiate a cycle stop or inhibit cycle start. The design shall allow the operator to perform a visual or manual check of the restraint each ride cycle.

NOTE — For some amusement rides, for example, roller coasters, freefall towers, the position of the restraint cannot be monitored continuously.

f) Means of activation — The restraint may be manually or automatically (for example, motorized) opened or closed.

g) Redundancy of locking device — Redundancy shall be provided for the locking device function.

h) Monitoring of locking device — The locking device shall be periodically tested prior to being put into operation with a guest. The frequency and procedure of such a periodic test shall be determined by the mechanical design.

Class 5: A redundant locking restraint device for each individual passenger. A Class-5 restraint device shall have at least the following:

a) Number of passengers per restraint device — A restraint device shall be provided for each individual passenger.

b) Final locking position relative to the passenger — The final locking position of the restraint shall be adjustable in relation to the passengers, for example, a bar or a rail with multiple positions.

c) Type of locking — The restraint device shall be automatically locked.

d) Type of unlocking — Only the operator shall manually or automatically unlock the restraint.

e) Restraint position monitoring — In addition to the operator responsibilities an independent restraint position monitoring system shall initiate a cycle stop or inhibit cycle start. The design shall allow the operator to perform a visual or manual check of the restraint each ride cycle.

NOTE — For some amusement rides for example, roller coasters, freefall towers, etc. the position of the restraint cannot be monitored continuously.

f) Means of activation — The restraint may be manually or automatically (for example, motorized) opened or closed.

g) Redundancy of locking device — Redundancy shall be provided for the locking device function.

h) Monitoring of locking devices — Direct position monitoring of the locking devices shall be required prior to the start of a new ride cycle. In case of a failure, a start shall be inhibited. As an accepted alternative the integrity of the redundant locking devices shall be verified within every two ride cycles.

j) Restraint configuration — Two restraints, for example, a shoulder and lap bar per passenger or one fail-safe restraint device are required (*see* **8.2.1** for secondary restraint device requirements).

Table 6 Minimum Requirements of Passenger Restraint Classes
(*Clause* 8.2)

Sl. No. (1)	***Class*** (2)	***1*** (3)	***2*** (4)	***3*** (5)	***4*** (6)	***5*** (7)
i)	No. of passengers per restraint	No restraint	Individual or collective for two or more passengers	Individual or collective for two or more passengers	Individual for each passenger	Individual for each passenger
ii)	Final latching/locking position	No restraint	Non-adjustable latching	Adjustable latching to passenger	Adjustable latching to passenger	Adjustable latching to passenger
iii)	Latching/locking	No restraint	Manually or automatically latching	Manually or automatically latching	Automatically locking	Automatically locking
iv)	Unlatching/Unlocking	No restraint	Unlatching by the passenger (manually) or operator (manually or automatically)	Unlatching by the passenger (manually) or operator (manually or automatically)	Unlocking by the operator manually or automatically	Unlocking by the operator manually or automatically
v)	Restraint device monitoring	None	None	None	Position of the restraint device	Position of the restraint device
vi)	Means of activation	None	Manually or automatically opened or closed	Manually or automatically opened or closed	Manually or automatically opened or closed	Manually or automatically opened or closed
vii)	Redundancy	None	None	Latching device	Locking device	Locking device and restraint device
viii)	Latching/locking device monitoring	None	None	Redundancy check	Redundancy check	Direct locking device monitoring

8.2.1 *Secondary Restraint Device for Class5 Restraints*

If, in addition to the primary restraint device, which complies with the above mentioned requirements, a secondary device is present and necessary, the secondary device shall have at least the following characteristics:

a) Collective;
b) Not adjustable;
c) Manually locked by the passenger;
d) Manually unlocked by operators or attendants;
e) No warning at all;
f) Redundancy only concerning locking device (functional).

Otherwise, this secondary device may be the containment enclosure or collective cage.

8.3 Amusement Rides With the Horizontal Axis

8.3.1 *General*

These are devices moving around a horizontal axis. *See* Fig.12 to 14.

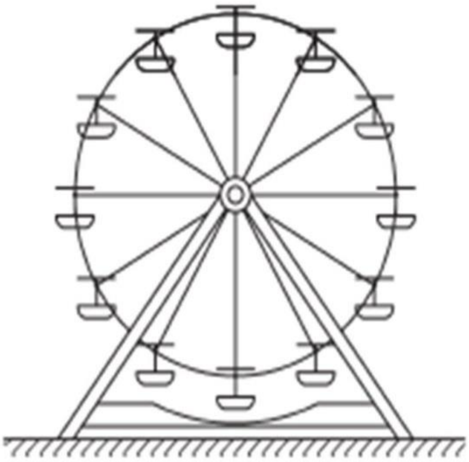


FIG. 12 MAIN HORIZONTAL AXIS (PASSENGER UNIT

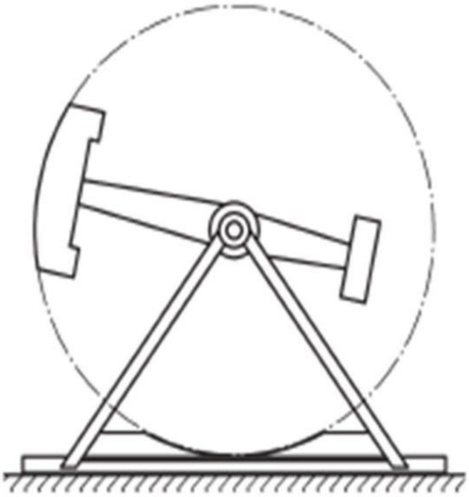


FIG. 13MAIN HORIZONTAL AXIS (PASSENGER UNIT NOT PIVOTING WITH MECHANICAL DRIVE)

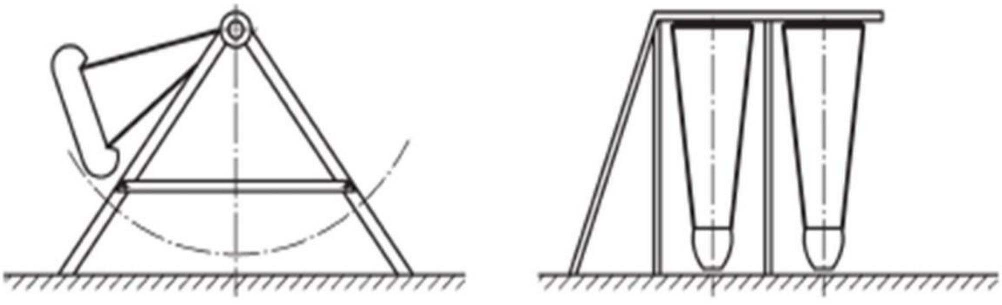


FIG. 14 MAIN HORIZONTAL AXIS (PASSENGER UNIT NOT PIVOTING AND WITHOUT MECHANICAI DRIVE)

8.4 Rail-guided channel or track-bound devices

8.4.1 General *See* Fig.15.

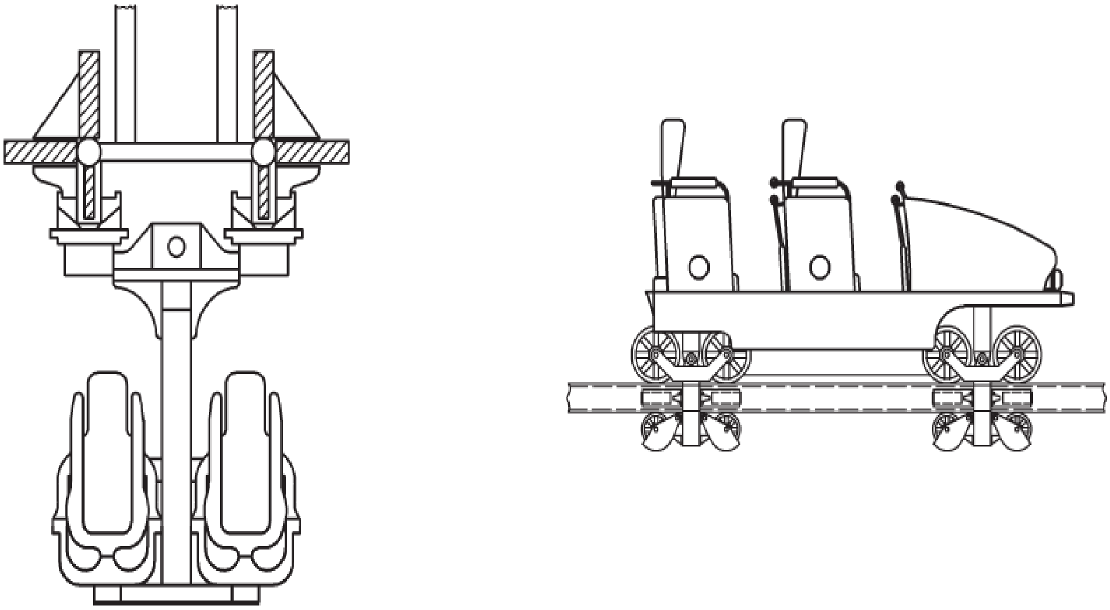


FIG. 15 TRACK-GUIDED DEVICES

8.4.2 Area separation systems and access and egress openings Area separation systems for the general public shall comply with J_3 requirements

Access openings to the loading zones shall comply with K_3 requirements in order to prevent access of passengers until the train comes to a stop. Egress openings shall comply with K_3 requirements.

Power-operated, rail-guided devices for children where the velocity does not exceed 2 m/s and where they are capable of being stopped within 2 m by the operator, shall be provided with an area separation system complying with J_2 requirements. Access and egress openings shall comply with K_2 requirements.

Miniature railways do not require an area separation system in amusement parks where all of the following conditions are met:

a) the train route is clearly isolated from other amusement devices, shops, or roads;
b) the train is driven by an operator;
c) train's velocity does not exceed 5 m/s;
d) acoustic warnings are provided on the train;
e) acoustic and optical warnings are provided on level-crossings;
f) The station area separation system shall comply with J_1 requirements**.**

8.4.3 *Passenger Units*

The passenger units shall be designed in such a way that:

a) passengers inside and outside are not liable to come into contact with moving parts;
b) passenger's hands or arms are not liable to be crushed or bruised by contact with the cars in front or behind the one they are traveling in;
c) the chassis and superstructures of the vehicles have sufficient degrees of freedom and clearance to follow changes in transverse inclination, curves, humps, and troughs while allowing for permissible wear.

Where there is contact between the cars or any guiding elements the cars shall be fitted with fenders at the front and/or rear, which are to be mounted at the same height. If there is a liability for offset during contact, for example, as a result of longitudinal or transverse swinging, then the fenders shall have a sufficient height to provide overlap.

At least one fender per car shall have shock-absorbing properties, the damping is designed as a response function to the nominal speed. Damping may be dispensed with if the cars are safeguarded against collision by a block-zone system or other equivalent means like sensors.

8.4.4 *Restraints*

Restraints shall be fitted where necessary in accordance with **8**.

8.4.5 *Miscellaneous*

The guiding elements of cars and trains shall ensure that contact with the track is maintained under all circumstances, by the provision of side guiding rollers, counter rollers, or equivalent systems adequate for the purpose. Special provisions shall be taken in the design of guiding elements in order to ensure that, even in the case of loss of one load wheel, side guide wheel, or up stop the wheel, the car or train cannot leave the rails. Wheel bandages, guide wheels, up-stop wheels are subject to wear. The permissible wear rates shall be specified by precise limits. Lateral movement of cars and gondolas shall be restricted to prevent collision with cars or gondolas on adjacent tracks or fixed objects. Safety distances have to be considered by using the extreme positions of the cars or gondolas. Pendulum gondolas, or similar passenger units, shall be provided with devices for limiting lateral or longitudinal oscillations of the gondola, during passenger loading and unloading.

8.4.6 *Roller Coaster Track*

8.4.6.1 *Brakes*

Safety brake zones shall be arranged in such a way that there will always be sufficient braking elements between any two cars/trains.

Safety brake zones shall be fail-safe and designed to stop the car or train in the most unfavourable conditions. Consequently, the brakes shall not lock or jam and shall be applied in a controlled and progressive manner.

A suitable redundancy of independent brake elements shall be provided and the brake shall stop the train/ vehicle for the most unfavourable condition with sufficient safety margin even in the case of a pressure drop in the brake system or a power loss.

The mechanical parts of the brake elements shall be designed and calculated with the appropriate partial safety factors.

In the event of delays during passenger loading, any risk of collision by following cars shall be prevented with certainty by appropriate means.

All functions and operational states of the safety brake system shall be controlled and monitored by a safety-related control system.

Operating fluid pressure and the acceptable pressure limits of each brake element shall be kept automatically controlled by the safety-related control system.

Operational brakes shall be provided to stop the cars or trains automatically in the shortest practicable stopping distance, taking into account the maximum permissible deceleration (*see* also **5.6.2.4**).

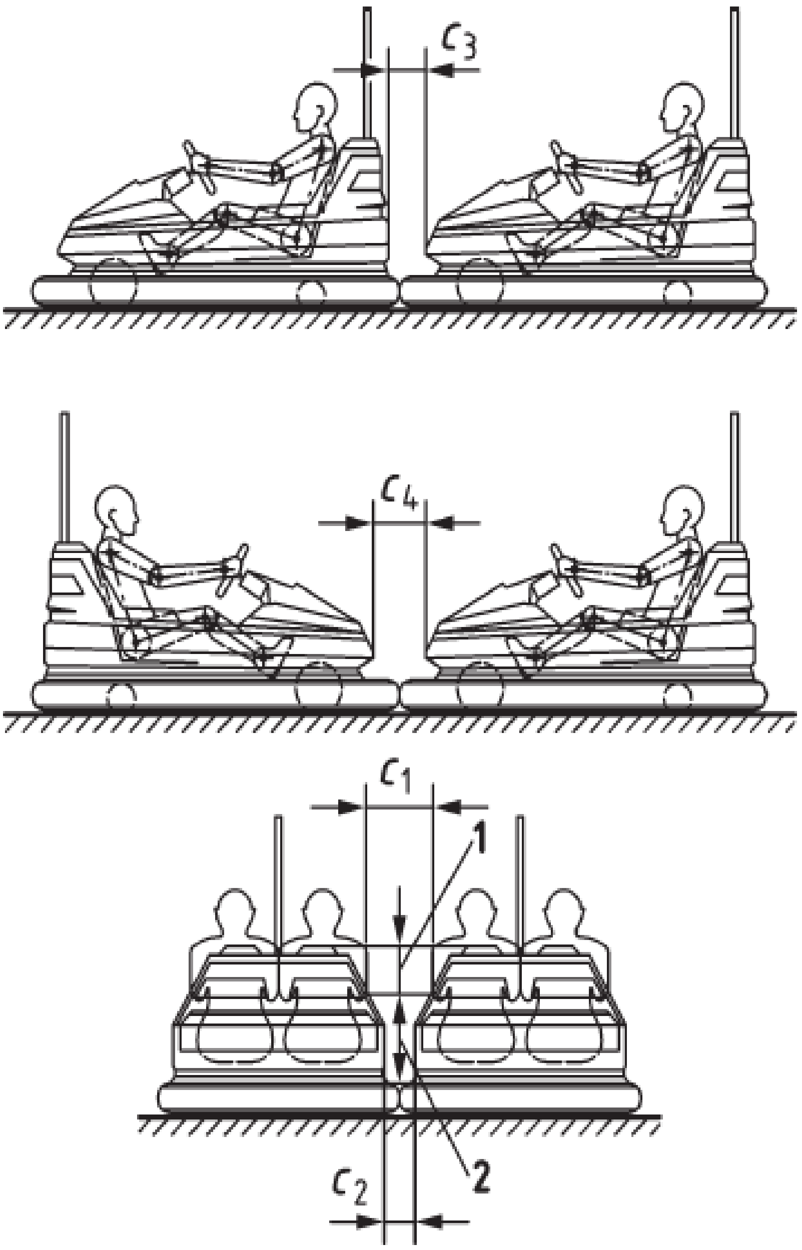
Maximum deceleration shall not exceed 0.7g for an emergency and 0.5g for normal stopping brakes (service brakes) unless special provisions for passengers are installed (lap bars, etc.)

8.4.7 *Dodgem/Bumper Cars*

For bumper cars, the minimum safety distances given in Table 7 shall be provided. *See* Fig. 16

Table 7 Safety Distances for Dodgem Cars
(*Clause* 7.1, 8.5.1)

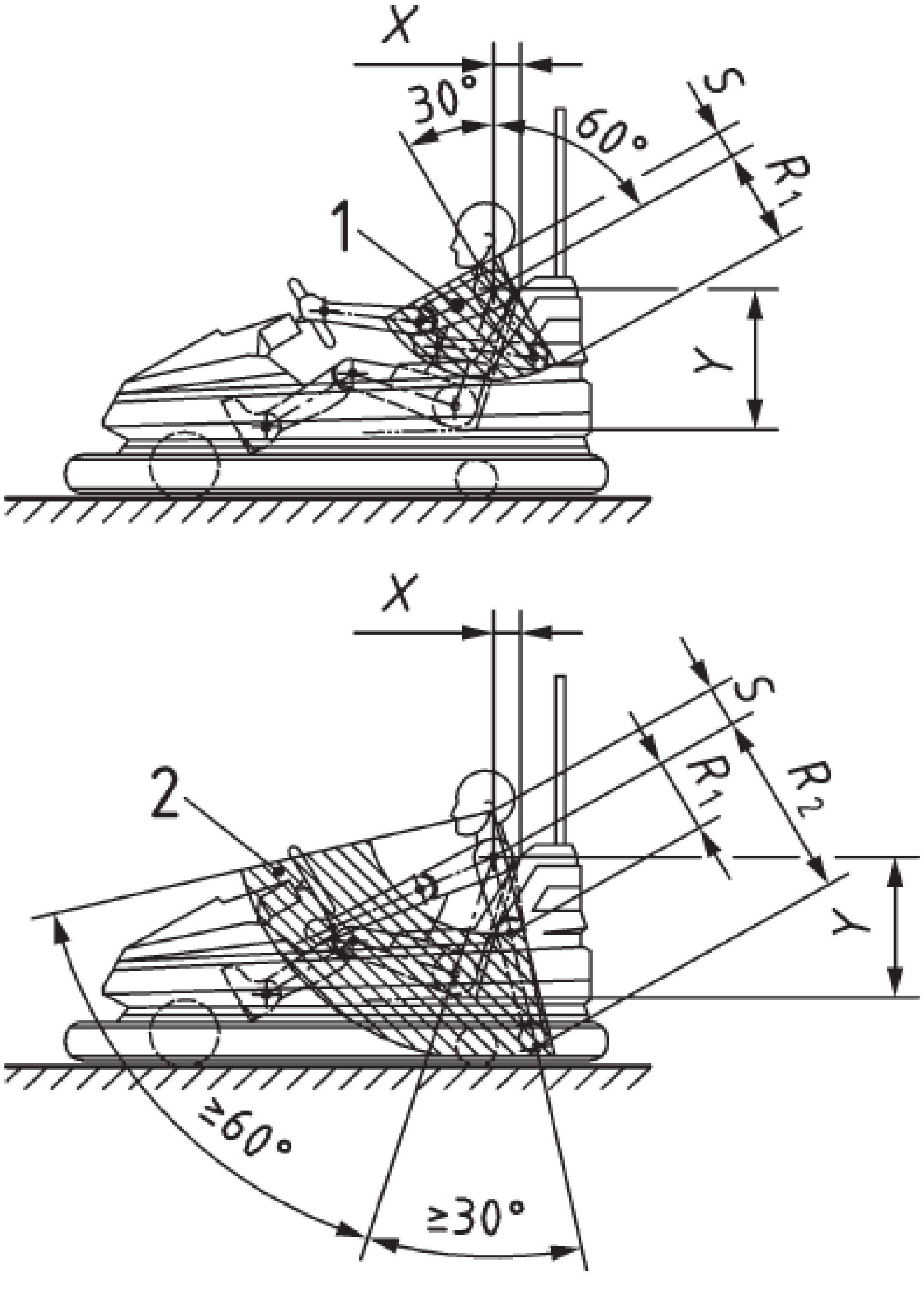
Sl. No.	**Classes (defined by passenger height or age)**		**X**	**Y**	**S**	**R_1**	**R2**	**C_1**	**C_2**	**C_3**	**C_4**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i.	Passengers from 4 to 8 years	*Min*	70	320	25	175	400	70	45	90	100
ii.		*Max*	85	400	30	230	515				
iii.	Passengers from 8 to 12 years	*Min*	85	400	30	230	515	85	60	120	150
iv.		*Max*	100	435	35	275	620				
v.	Passengers and accompanied children	*Min*	100	435	35	275	620	100	85	140	200
vi.		*Max*	120	550	50	310	725				
vii.	C_1, C_2, C_3, and C_4 are minimum clearances (empty spaces) between the rigid parts of the bodywork (excluding rubber protections and the like which can cause no damage) in a static position.										



Key

1 — Zone 1
2 — Zone 2
C_1–C_4 — Minimum clearances (*see* Table 7)

Fig. 16 Dodgem/Bumper Cars



Key

1 — Zone 1
2 — Zone 2
X, Y, S, R_1, R_2 — Safety distances for dodgem cars (*see* Table 7)

FIG. 17 DODGEM/BUMPER CARS

8.4.7.1 *Area Separation System and Access and Egress Openings*

Area separation system for the general public to the driving area shall comply with J_1 requirements. Access and egress shall comply with K_1. The driving area shall be surrounded by a sill of sufficient height, so as to prevent mounting by the car. Spring supported sills are not permitted. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

8.4.7.2 *Passenger Units*

Dodgem car vehicles shall be designed so that passengers cannot fall out. The vehicles are to be surrounded by buffers made of soft material or inflatable tyres, which shall project sufficiently to provide the clearances given in **8.5.1**. The buffers fitted to vehicles that are used on the same ride shall be set at the same height for all vehicles and at the same height as the edge of the sill or barrier.

All moving or other dangerous parts of the vehicles which could cause injury, shall either be

a) Designed so as to remove the risk of injury; or
b) So protected as to minimize injury by impact.

8.4.7.3 *Restraints*

Dodgem cars shall be fitted with safety belts or other equally effective devices which will prevent children from being injured on impact with other vehicles. Where belts are fitted they shall be at least 25 mm in width.

8.4.7.4 *Miscellaneous*

The driving area shall be free from discontinuities, so as to prevent obstruction to the cars' movement.

Dodgem cars shall be designed in such a way as to minimize the risk of overturning.

The speed of dodgem cars shall not exceed 12 km/h. Cars to be used by unaccompanied children, aged 8 years or less, shall be limited to a maximum speed of 8 km/h if the risk assessment demonstrates safe to use.

Where high-efficiency shock-absorbing systems are provided the speed may be increased to 14 km/h, if the impact forces do not exceed the forces attained in a conventional dodgem car travelling up to 12 km/h.

The maximum speed of vehicles operating on the same track shall not vary by more than 15 percent. The mass difference of loaded cars (*see* **5.3.1.2**) operating on the same track shall not exceed 30 percent.

Where high-efficiency shock-absorbing systems are provided the mass difference may be increased.

The installation shall be fitted with an emergency stop device, which enables the operator to stop all vehicles from his control position.

8.4.7.5 *Electromechanical Requirements for Dodgem Cars*

Conducting parts of cars that are not protected from direct touching, shall be powered with a maximum of 25 V a.c. or 60 V ripple-free (max. 10 percent ripple) d.c. supplied by a safety isolating transformer in accordance with IS 2026 (Part 1).

For those conductors out of normal reach (heights at least 2.5 m above the floor pan of the vehicle), the maximum voltage shall not be more than 50 V a.c. or 120 V ripple-free d.c., i.e. a maximum of 10 percent ripple supplied by a safety isolating transformer in accordance with IEC 61558-1 or an equivalent a.c. or d.c. generator.

Exposed electrical conductors shall be at least 2.5 m above the floor pan of the vehicle.

The overhead current supply net or plate, the collectors on the vehicles, and the track shall be designed and built in such a manner that injury will be minimized paying particular attention to the eyes as a result of particles and sparks.

For driving areas of up to 200 m^2 the current supply net or plate shall be securely attached to the power supply at a minimum of 2 points. For areas greater than 200 m^2 a minimum of 3 supply points shall be fitted.

Any current supply net shall be of wire mesh (preferably hexagonal) with a diameter of wire between 1.2 mm and 1.4 mm. The square hole size of the mesh shall not exceed 40 mm × 40 mm.

As well as steel other suitable materials (for example, copper, brass, aluminium) may be used.

Nets shall be tensioned with plates fixed in such a manner that no significant deformation or movement due to the pressure of the collectors will occur.

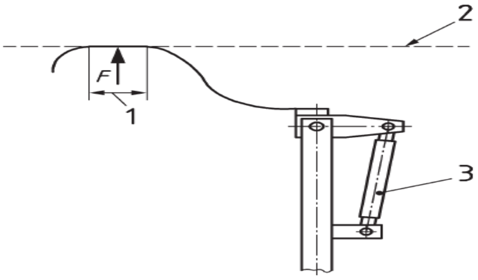
Steel wires shall be galvanized before being joined by wire wrapping. The current supply net shall be fixed at a uniform distance of not less than 2.5 m above the floor pan of the vehicle.

Any current supply net shall be of galvanized steel or be of a suitable alternative material (for example, copper, brass, aluminium).

The vehicles shall be equipped with contact brushes made of steel or bronze, which are spring-loaded against the floor with a force F of at least 10 N (*Fig*. 19).

The current collector (*see Fig*.18) shall be made of steel and formed with the largest radius possible, so as to touch the current collector net at a minimum of three points. It should swivel easily and exert a constant force F on the supply network of at least 10 N. Steel or other suitable alternative materials (for example, copper, brass, aluminium) may be used.

The connections to the net shall be equally spaced around the perimeter of the net or plate.

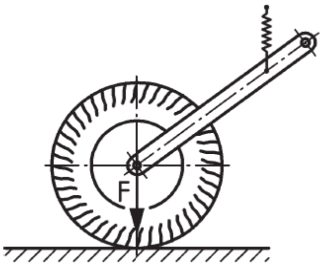


Key

1 contact area
2 net
3 spring
F contact force

FIG. 18 EXAMPLE OF A TYPICAL NET CURRENT

The plates which form the track shall be smooth; panels shall have good electrical contact through the edges or by other means. They shall be connected to the negative pole of the energy source at two opposite points in order to avoid dangerous potential differences. The plates of the track shall be connected to all metallic surrounding structures.



Key

F contact force

FIG. 19 CONTACT FORCE OF A FLOOR CONTACT BRUSH

SPEEDWAYS/GO-KARTS

9.1 These requirements are specific for amusement parks and fairground go-karts.

9.1.1 Area separation system and access and egress openings In order to prevent the general public from walking onto the track, the speedway tracks shall be guarded by a guard rail at least 0.5 m above the hill of the track but in any case at least 1.1 m above the floor level accessible to the public (area separation system complying with J_3 requirements). Access and egress shall comply with K_2 requirements. The driving area shall be surrounded by a barrier of sufficient height so as to prevent mounting by the car. Spring-supported barriers are not permitted. The sill shall be strong enough to withstand the impact of the cars at maximum speed.

9.1.2 *Passenger Units*

The speedway track and cars shall be designed in such a way as to minimize the risk of overturning. Factors such as speed, inclination, bend radii, and width of track shall be taken into consideration. Where overtaking is possible the track shall be at least three times the maximum width of the speedway car. Speedway cars shall be surrounded by fenders so as to prevent any contact between the respective wheels and/or the frames of the cars.

9.1.3 *Restraints*

Speedway cars shall be provided with adjustable diagonal shoulder belts on each passenger seat, of at least 25 mm in width, while respecting the following minimum requirements as defined in passenger restrain.

9.1.4 *Miscellaneous*

The speed of cars running on a speedway shall not exceed 30 km/h.

Cars to be used by unaccompanied children aged 8 years or less shall be limited to a maximum speed of 8 km/h if the risk assessment demonstrates safe to use.

Cars driven by internal combustion engines shall be fitted with a tray beneath the engine and the fuel lines.

The engine shall be positioned such that passengers are not endangered by an engine fire. ISO 1204 and ISO 3046 on fuel-driven engines shall be considered.

The driving area shall be smooth and level and shall be constructed of material appropriate for that purpose.

The installation shall be fitted with a device that enables the operator to stop all vehicles.

10 MANUFACTURING PROCEDURE AND QUALITY CONTROL

10.1 Approval of Design

Before commencing manufacture, the manufacturer, if so desired shall submit for approval by the approved agency/statutory authority a fully dimensioned drawing with all the relevant information including calculation of loads, stresses and engineering specifications.

10.2 Drawing Control Procedure

A procedure shall be in effect so that appropriate manufacturing drawing, their engineering machine design calculation, specifications and related documents are arranged in a proper manner and utilized for each project.

10.3 Material and Component Control Procedure

A procedure shall be in effect so that materials, processes, and components, including raw materials, are in accordance with the recommended engineering specifications.

10.3.1 This procedure shall provide the purchase department/section with all the information required to order appropriate/specified material.

10.3.2 A receiving procedure shall be in effect so that incoming material and components are checked against the desired specifications and non-conforming components shall be identified and disposed of to avoid accidental use.

10.3.3 A procedure shall be in effect so that material in stock can be properly identified for use as and when required in the future.

10.4 Inspection Procedure

A procedure shall be in effect so that stage inspections are made on manufactured parts and subassemblies, for conformance with recommended engineering specifications prior to use in the next stage of construction.

10.5 Welding

Welded construction of the ride or device is subjected to the following general conditions:

10.5.1 All details of design and construction shall generally conform to the provisions of the relevant standards given in Annex B.

10.5.2 The welders shall be qualified for the type of welding concerned in conformity with the welder’s performance qualification such as confirming to Welder Performance Qualification (WPQ). This is a test certificate that shows whether a welder possesses the necessary experience and knowledge to perform the specifications of a particular weld procedure.

10.5.3 The manufacturer of the ride or device shall be responsible for all the welding work done as per relevant standards given in Annex B or as recommended by the approving authority or buyer.

10.5.4 The manufacturer shall conduct the tests required to qualify the welding procedure employed and to assess the performance of the welders who apply the recommended welding procedure.

10.5.5 The manufacturer shall maintain a record of the results obtained in welding procedure qualification tests. These records giving an accurate description of all the particulars of the materials and procedure shall be certified by him and shall be accessible to the inspecting authority who should be permitted to witness the tests if he so desires.

10.5.6 The materials shall be as per approved drawings conforming to relevant standards given in Annex B.

10.6 Bolted and Rivets Joints

All threaded fasteners and rivets used on an amusement ride or device in connecting components and parts shall meet the specified requirements of IS 1364 or IS 3757 for each application in the system, and grade shall be identified where appropriate. Lock nuts may be used in order to prevent the loosening of bolts during dynamic loading. IS 15475 (Part 1) may be referred for bolts, nuts, rivets, and fasteners.

10.7 Forgings and Casting

Forgings and castings used in ride systems shall meet the recommendations of IS 2004, IS 210, IS 1030, IS 2644 for each application in the system, and grade/type shall be identified IS 15475 (Part 1) General information may be referred for forgings and castings.

10.8 Chain and Wire Rope

Chain and wire rope used in ride systems shall comply with the specified requirements of IS 3109, IS 2266. IS 15475 (Part 1) may be referred to considering existing industrial rating, load conditions, dynamics, and potential fatigue involved.

10.9 Gears

Gear, rack, and pinions used in ride systems shall comply with the specified requirements of IS 2535, IS 3734 and IS 5037

10.10 Conveyor and Elevator Belts

Conveyor and elevator belts used in ride systems shall comply with the specified requirements of IS 1891 (Part 1), IS 1891 (Part 2), IS 1891 (Part 3), IS 1891 (Part 4), and IS 1891 (Part 5).

10.11 Air Supported Structures

Where applicable, air-supported structures shall be designed and manufactured with flame-resistant materials.

10.11.1 Hold-down provisions shall be made for the structure to allow operation of the device within wind conditions.

10.11.2 Provisions shall be made to ensure that patrons cannot conceal themselves from the operator's view in a normal ride position.

10.11.3 Enclosed structures shall have within 30 m of the normal point of egress adequately lighted emergency exits.

10.11.4 Power failure, of an inflation means, shall not increase the risk of injury to anyone on the device.

10.12 Electrical System

10.12.1 Unless otherwise specified, all electrical items such as equipment, appliances, switchgear, control relays, cables, conductors and accessories, etc, used in construction, operation, testing, and maintenance of amusement ride or amusement device shall comply with the specified requirements of SP 30 and relevant Indian Standards were available. A list of such Indian Standards for guidance is given in Annex C. The manufacturer shall declare standards used from Annex B for Electrical System.

10.12.2 Electrical Wiring shall be According to IS 732.

10.12.3 Emergency stop circuits shall be energized systems that are fail-safe in case of power failure.

10.12.4 The emergency stop switches shall be manually reset. The resetting of the stop switch shall not start the ride.

10.13 Hydraulic Fluid Power Systems

10.13.1 Hydraulic components used in hydraulic fluid power systems shall comply with specified requirements of appropriate Indian Standards. For guidance, a list of Indian Standards on hydraulic fluid power systems and components is given in Annex D**.** The manufacturer shall declare standards used from Annex C for Hydraulic Fluid Systems.

10.13.2 Hydraulic components used in the ride system and device shall be suitable for higher temperature operation and adequate shielding shall be provided to prevent hot fluid from reaching any passenger or observer on or near the ride or device.

10.13.3 Adjustments of control should not require access between, over, or in close proximity to moving parts.

10.13.4 Emergency safety device or means shall be provided in the proportional or servo control circuit in order to prevent undesirable motion of the ride.

10.13.5 Filters should be sized to provide a minimum of 800 h of operation under normal working conditions.

10.13.6 Diagnostic pressure test points, when used should be accessibly installed in hydraulic circuits to verify system pressure and also where pressure can be adjusted from the main system pressure.

10.13.7 *Oil Sampling*

Sample test points shall be made available close to hydraulic pumps and other key positions for the purpose of checking fluid for contamination. Under full system pressure, safe access to sample test points shall be ensured.

10.13.8 *Position Limits*

Effective provisions shall be made to prevent a linear actuator beyond the desired limits where the piston and piston rod diameter are the same.

10.13.9 *System Failures*

The controlling mechanism shall be provided to control the forces acting on the passengers on account of change in velocity or acceleration in the event of hydraulic system failure or malfunctioning.

10.14 Pneumatic Fluid Power Systems

10.14.1 Application and installation of a pneumatic fluid power system shall be in accordance with IS 12725.

10.14.2 Sizes for bores and port threads for pneumatic fluid power cylinders shall be as per recommendations of IS 8526.

10.14.3 Mounting dimensions of pneumatic fluid power cylinders shall be in accordance with IS 10143, IS 12723, IS 12738, IS 13086 and IS 13087 based on bore size and type of mounting.

10.14.4 Maximum pneumatic pressure shall not exceed the component rating.

10.14.5 Pneumatic fluid power accumulators shall conform to IS 11277 or ISO 5596.

10.14.6 Pneumatic tubing hose and fittings shall conform to IS 7651.

10.14.7 Provisions shall be made to cause the system to revert to the appropriate emergency mode in the event of pressure drops below the minimum design pressure in critical applications.

10.14.8 The system shall include the components for lubrication and moisture extraction, where deemed appropriate by the designer/manufacturer.

10.15 Brakes

10.15.1 Sufficient braking capacity shall be provided to satisfy the designer's recommended operation parameters.

10.15.2 Provision shall be made for a block system of braking for those rides or devices where it is necessary to prevent independent passenger-carrying units from occupying the same block section of the ride.

10.15.3 Where appropriate critical braking system shall remain energized and activated even when the regular power supply fails.

10.15.4 Operator monitored braking system may be provided which normally activated in the absence of the operator.

10.16 Operator Controls

Operator controls shall be located within easy reach of the operator when the operator is in a position to observe the ride while the ride is in operation.

10.16.1 Operator control system shall be capable to avoid unintentional activation.

10.16.2 Operator control shall be identified in English along with Hindi or applicable local language with respect to their function.

10.16.3 Control access system shall be incorporated in the operator control mechanism.

10.17 Machine Guards

Suitable machine guards shall be provided to protect employees, operators, and guests from hazards associated with but not limited to, belts, chains, and pulleys.

11 FENCING

11.1 Provisions shall be made to protect the spectators and riders. The fences and gates shall be constructed considering the following minimum requirements.

11.1.1 Height of fences and gates shall be at least 1.1 m above the surface on which spectators and riders stand.

11.1.2 All openings provided shall be able to reject a ball of 100 mm size, fabricated with vertical bars only without any horizontal designs or bars, to inhibit any climbing over the fencing.

11.1.3 These shall be designed, constructed, and erected to inhibit overturning by spectators and riders.

11.1.4 Entrance, exit, and loading gates shall open away from the ride or device or shall be equipped with a positive latching device. In the case of a hinged door, clearance of 40 mm shall be maintained in all movements.

11.1.5 The gates if opened during operation of ride or devices shall have sufficient clearance in order to avoid contact or hazard to riders/operator.

11.1.6 The fences and gates shall be able to avoid contact with rides or devices and also with riders.

11.1.7 Horizontal members may be used to improve construction or efficiency. However, these should be minimized to reduce the ease of climbing.

12 GENERAL CHARACTERISTICS FOR ERECTION

12.1 Suspended Gondola

Cradles shall be suspended from rigid distributor bars to prevent entanglement of support chains. Redundancy/backup systems shall be provided for all single-point suspensions of vehicles, sways, arms, and other patron-carrying components. The backup system may consist of chains, ropes, pins, or other structural members of adequate size and strength. Pin or bolt holes of the suspension and backup system shall be staggered to avoid the wrong assembly. For amusement rides where there is a risk of fall from a height of 2.5 meters or more, the cradles shall be suspended by 4 wire ropes or chains unless another fall protection system such as a fall arresting device and safety gear, etc. is in place. The anchoring position shall be suitably designed such that when one of the wire ropes breaks, the cradle shall remain reasonably stable and the tilting of the cradle shall not cause patrons to fall out.

12.2 Wire Ropes, Shackles and Pulleys

Suspension ropes shall be stranded steel wire ropes complying with IS 9282. Each rope shall be in one continuous length and free from joints or repairs. The minimum safety factor, the ratio between the minimum breaking load of the rope to the maximum rope tension, shall be at least 10 but a higher safety factor of up to 14 shall be considered where the circumstances warrant. Both ends of the wire rope shall be securely fastened and the strength of rope terminations shall be not less than 80 percent of the minimum breaking load of the rope. The wire ropes shall be properly guided throughout the path of travel. Pulleys shall be provided for all bends. All pulleys shall be fitted with self-lubricated bearings. The diameter of each pulley shall be compatible with the wire rope use. A suitable guidance device shall be provided to prevent the wire rope from slipping off the pulley.

12.3 Hydraulic System

12.3.1 Installation and Safety Features

Every component of the hydraulic system, which requires regular maintenance and adjustment, shall be accessible without risk from a safe working position. And the following safety features shall be incorporated into the design of the hydraulic circuit:

a) Safety devices to protect against the effects of failure of a hose in any hydraulic circuit which otherwise could affect the operational stability of the ride;
b) Overpressure protection on the discharge side of all pumps capable of handling the maximum flow of the pumps;
c) Overpressure protection of all load-bearing hydraulic cylinders.

12.4 Pneumatic System

12.4.1 *Installation and Safety Features*

Every component of the pneumatic system, which requires regular maintenance and adjustment, shall be accessible without risk from a safe working position. And the following safety features shall be incorporated into the design of the pneumatic circuit.

a) Safety devices to protect against the effects of failure of a hose in any pneumatic circuit which otherwise could affect the operational stability of the ride;
b) Pressure vessels shall be fitted with appropriate pressure relief valves. The discharge points shall be contained or directed so as to eliminate the risks of

contamination of equipment or injury to persons;

12.5 Electrical Requirements

All electrical works associated with the amusement ride shall comply with IS 732.

12.5.1 *High Voltage Installation*

High voltage electrical works [greater than 415 V (a.c.)], with the exception of cold-cathode illumination systems (for example, neon lights), shall be prohibited for amusement ride installation.

12.5.2 *Low Voltage Installation*

Where the power supply to an amusement ride is at low voltage [50 V to 415 V (a.c.) supply], it shall pass through an over-current circuit breaker of a rating appropriate to the current consumption of the connected load which may be either:

a) an isolating switch complying with and being type tested to IEC 947-3; or
b) a residual current device (RCD)/ELCB type tested to IEC 755; or
c) an air circuit breaker (ACB) or molded case circuit breaker (MCCB) complying with and being type tested to relevant industry standards or covered under Indian Electricity rules.

12.5.3 *Extra-low Voltage*

For extra-low voltage circuits [less than 50V (a.c. supply)] transformers shall either be inherently short-circuited proof or provided with overload and short-circuit protection. Bare conductors for extra-low voltage shall not be used.

12.5.4 *Equipotential Bonding Requirements*

All electrical installations, except at extra-low voltage, shall be earthed in accordance with the following requirements:

a) Where the power supply is taken from a permanent and fixed sub-main distribution system connected with the grid of the power supply company, all metalwork associated with the electrical installation not forming part of a live conductor, shall be solidly and effectively bonded and earthed in accordance with IS 3043;
b) Where power is obtained from a generator mounted on the frame of the amusement ride concerned, the electricity generating set shall comply with IS 10000, IS 10001 and IS 4889;
c) Where the power is generated on-site and the generator is positioned far from the amusement ride, the start point of the generator and the generator frame shall be solidly bonded to an earthing electrode driven for the purpose. While the ride and the generator frame shall be connected together with an earthing conductor of ample size in accordance with IS 3043 as if the source of supply were a mains supply.

12.5.5 *Free-standing Motor Control Switchboard*

a) The motor control switchboard (hereafter called the “Switchboard”) shall be a free-standing floor-mounted low voltage switchboard to group centrally the motor starters, controls, and switchgear for various electrical equipment associated with the amusement rides;
b) The multi-cubicle type assembled “Switchboard” shall conform to an established type “Switchboard” which has been verified to be in accordance with IS 3854 and IS 1293 by a recognized testing authority;
c) “Switchboard” shall be constructed generally to be of the degree of protection of IP 31 for indoor application and IP 54 for outdoor locations;
d) The “Switchboard” shall be clearly marked and labelled with the safety signs, circuits controlled and electrical characteristics of the “Switchboard”.

12.5.6 *Isolating Switch*

Every amusement ride that is connected to any power supply shall be provided with an isolating switch in a position readily accessible to the maintenance personnel who are supposed to work in the vicinity of the Main Motor Control Switchboard of the ride in question.

12.5.7 *Emergency Lighting*

Adequate emergency lighting and illuminated exit signs shall be installed for the safe operation of the amusement ride in accordance with the IS 1641, IS 1642, IS 1643, IS 1644, and IS 1646. For rides that need a waiver of this statutory requirement because of safety reasons, the ride owner shall apply to Fire Services Department for exemption.

12.5.8 *Power Point below 2.5 m*

Where the public is admitted, the electric power supply to motors, equipment, lighting, and socket-outlets installed on the moving parts of an amusement ride and to all other lighting outlets less than 2.5 m above the floor level or within the arms reach shall be protected by one of the following:

a) A residual current device (RCD)/ELCB;
b) An isolating switch complying with and being type-tested;
c) An extra-low voltage system obtained from the non-earthed secondary of an isolating transformer.

12.5.9 *Other Requirements*

a) Any cable passing under an amusement ride or within 1 000 mm of any moving part there of shall be provided with mechanical protection;
b) Exposed lamps, except where supplied by extra-low voltage, or protected by a residual current device, shall not be installed within an arm-reach distance of any position accessible to the public;
c) All electrical terminations and connections shall be capable of withstanding the effects of any expected vibration and movement;
d) Power supply to the control devices handled by patrons shall be an extra-low voltage supply only;
e) Pendant, roving controls, or any control handled by operating staff shall be either double insulated or designed for connection to an extra-low voltage supply only.

12.5.10 *Flexible Cable and Plug*

a) The supply cord and other connecting cables shall be of the heavy-duty type and shall be mechanically protected where necessary;
b) The removal of a single access cover to a coin container, coin mechanism, or other similar components shall not cause any live part or basic insulation to be exposed;
c) Every drive motor and all exposed metal parts of the equipment shall be effectively earthed to the main earth via a circuit protective conductor.

12.5.11 *Electrified Metallic Grid*

Where an amusement ride involves an electrified metallic grid installed over an area accessible to the public, the electrified metallic grid shall be installed at a height of at least 2.5 m above floor level and the supply voltage shall not exceed 120V d.c.

12.6 Ride Control Equipment

The control panel and the associated control equipment for the amusement ride shall be designed with due regard to the following:

a) The location of the control station and the remote annunciation panels shall be carefully selected so as to minimize any interference by the patrons or the passers-by and to Standard Spec. Allow the Chief Operator at the control station to have an unobstructed view of the embarking and disembarking process;
b) The Chief Operator shall be able to have direct or supervisory control of all functions for embarking, disembarking, interlocking and emergency from the supervisory panel at the control point;
c) Visual indicators should be installed, where necessary, to show the operational status of the equipment. For abnormal status or signal of the safety-related devices, provisions of audible alarms shall be available;
d) Where an amusement ride has remote areas or areas obscured from the view of the Chief Operator at the main control station, means of observing and communicating with patrons, such as CCTV system, intercom system or public address system, shall be provided, otherwise; a risk assessment has to be conducted if such provisions are considered not practicable;
e) The controls and indicators on the mimic panel shall be arranged in such a way that the natural directional movement of the signals or physical control actions corresponds with the actual movement of the vehicles;
f) Any emergency stop action shall bring the ride to a stop in a safe manner. The emergency stop system shall not rely on electronic equipment for its operation and shall only be reset manually. The emergency stop push-button shall be prominent and located for immediate access by the ride attendants.

12.7 Lightning Protection

For outdoor amusement rides involving tall and massive structures, an assessment of the risk of being struck shall be made. Weighting factors at the higher end shall be used for assessment on mobile rides or where the patrons would expose at the highest levels of the structure. If provisions of lightning protection are determined to be necessary, all the design works shall conform to IS 62305 (Section 1).

12.8 Steam and Gas Propelled Equipment

a) All boilers and steam receivers associated with the amusement rides shall comply with the requirements of Boiler and Pressure Vessels Ordinance, Chapter 56 in respect of registration, maintenance, and examination of the pressure vessels;

b) Only the low-pressure steam or hot water boilers are permitted to use in connection with the amusement ride installation;
c) Hot water boilers and burners shall be constructed to IS 13980 respectively. All the exposed surfaces, including the associated pipeworks and accessories, shall be insulated such that the surface temperature at any location shall not exceed 40°C;
d) Provisions of safety devices including double safety valves, automatic low water level cutout, over-temperature protection thermostat, automatic firing controls shall be provided;
e) Where hot air is used in conjunction with an amusement ride other than hot air balloon, all the exposed ducting, diffusers, or other delivery systems shall be insulated with surface temperature not exceeding 40°C whereas the air heating equipment should be designed, controlled and operated to prevent the temperature of hot air from reaching beyond 60°C.

12.9 Fire Protection

If the passenger of an amusement ride is totally enclosed in a cabin, all the upholstered furniture inside the cabin shall be verified to comply with IS 3809 or IS 1642). Subject to risk level, automatic fire fighting equipment (for example, sprinkler heads) shall be provided if deemed necessary.

12.10 Propulsion System and Associated Protection Mechanism

Propelling machinery of the amusement ride shall comply with the following requirements.

12.10.1 *Protection for Overspeed*

For the ride (for example, a vertical ride involving a traction drive in the course of descending), where there is a concern on the overspeed issue, the drive shall be fitted with sensors or devices, which should be able to trigger a mechanism to shut down the drive in a safe manner whenever the designed maximum speed is exceeded. Overspeed sensors and controls shall be fail-safe and able to be positively tested by a regular and simple method, which shall be detailed in the operation and maintenance manual.

12.10.2 *Protection for Underspeed*

Where an underspeed condition may endanger the patrons (for example, a vehicle is maintained inverted by centrifugal forces), the drive shall be fitted with an underspeed sensor to trigger a mechanism, which shall prevent the vehicle from reaching a dangerous orientation until the correct speed is attained. The vehicle shall be able to restore to a safe orientation immediately upon loss of speed. Underspeed sensor and control shall be fail-safe and shall be able to be positively tested by a regular and simple method which shall be detailed in the operation and maintenance manual. Underspeed sensor and control shall not be able to be reset except by a full shut down and restart of the ride. An alarm signal shall be given when the propelling machinery is tripped.

12.10.3 *Manual Winding*

Retrieval of patrons may be stranded by the failure of the driving system (for example, loss of power), the ride shall incorporate either a means of manually winding the machinery back to a safe position or a means of emergency disembarkation in accordance with **12.14** regarding evacuation. If the ride is of a size/configuration that manual winding is not practical, an emergency power system shall be installed for patron retrieval.

12.11 *Vehicle Body*

All the vehicle surfaces with which the riders may come in contact shall be rounded and smooth, free from sharp, rough, or splintered edges and corners, and have no protruding studs, bolts, screws, or other projections. Adequate padding shall be provided where the patron may be thrown upon or against any part of the vehicle due to the ride motion. For amusement rides involving more than one vehicle, the body of every vehicle shall be provided with clear, unique, and identifiable markings.

12.12 Safety Clearance and Envelope

Any fixed or moving object, structure, or special effect, which the vehicles may pass during the operation of the ride, shall be beyond the reach of the rider. Apart from this general principle, some specific requirements on the safety envelope, as well as the key dimensions of the seating, are set out in the following as guidance. The approval shall be sought if an alternative design standard on the safety clearance is adopted.

12.12.1 *Fully Enclosed Vehicle*

For rides where the patrons are totally enclosed inside a cabinet whilst there are some openings on the casing, the minimum clearance from adjacent objects shall be:

a) minimum safety clearance = 90 mm, where opening size < 9 mm;
b) minimum safety clearance = 150 mm, where 9 mm ≤ opening size < 50 mm.

12.12.2 *Restrained Patrons in Open Type Vehicle*

If patrons are not totally enclosed but are effectively restrained in the seat, the following requirements as to dimensions of the seat and the safety clearances in relation to the seat shall be observed.

a) The upper safety space, 1 500mm extending upwards from the seating surface, shall not be obstructed by any external objects;
b) The height of seat back (H_{back}), under the different angle of seat rest (θ), shall be high enough such that
    1) minimum H_{back} required = 400 mm, where $0° \leq \theta < 15°$;
    2) minimum H_{back} required = 550 mm, where $15° \leq \theta < 30°$;
    3) minimum H_{back} required = 700 mm, where $30° \leq \theta < 45°$;
    4) minimum H_{back} required = 800 mm, where $45° \leq \theta < 90°$;
    5) minimum H_{back} required = 900 mm, where $90° \leq \theta$.

    (where θ is the inclination of the seat back measured from a vertical plane while H_{back} is the height of the seat back measured from the seating surface to the top edge of the seat back)
c) If θ exceeds 45° in the course of motion, a rigid over-shoulder restraint system shall also be provided;
d) The lateral safety space, which extends laterally outwards from the edges of the seating frame up to a distance R_{lateral}, the value of which shall be determined as a function of the Height of Seat Side (Hss), shall not be obstructed by any external objects:

Height of Seat Side (H_{ss})	R_{lateral}
Low seat sides: 200 mm ≤ H_{ss}< 400 mm	1 000 mm
Standard seat sides: 400 mm ≤ H_{ss}< 600 mm	750 mm
High seat sides: 600 mm ≤ H_{ss}	450 mm

e) For vehicle speed exceeding 3 m/s, low seat sides shall be avoided;
f) Where patrons are restrained but their legs are hanging free as in the suspension rides, a further bottom safety space, 900 mm extending downwards from the bottom of the seating and lateral safety space, shall be maintained.

12.12.3 *Unrestrained Patrons in Open Type Vehicle*

For open-type vehicles where patrons are not totally restrained in their seats, the following safety clearances shall be maintained.

a) The vertical safety space, 2 100 mm extending upwards from the floor, shall not be obstructed by any external objects;
b) The lateral safety space, 750 mm extending outwards from the outermost envelope of the vehicle, shall not be obstructed by any external objects. Vertical safety space is reduced from 2 400 mm to 2 100 mm to tally with the requirements in ride involving electric grid.

12.13 Maintenance Access

The fixed platforms, walkways, stairways, and ladders, which are used by the crew for operation, inspection, maintenance, or servicing purposes, shall be designed and constructed. Provisions of guarding and restraint systems shall be provided for the prevention of falls from height.

12.14 Evacuation Facilities

Appropriate means (hereunder called “assisted evacuation facilities”) shall be provided to facilitate the safe emergency disembarkation of patrons from the ride in cases of power failure, malfunction, fire or any unintended stoppage through:

a) Facilities to bring the ride to the loading/unloading points or other position where patrons can disembark in a safe manner;
b) Fixed walkways, stairs, platforms or hatchways that are readily accessible from all sections of the ride, with signs as appropriate; or
c) A combination of the above two means.

13 DEGREES OF POTENTIAL BIOMECHANICAL RISKS FOR AMUSEMENT RIDES

When people are being moved by an amusement ride, the respective potential risks of harm may be present depending on the potential fall height, values of velocity and accelerations, angle of the seat inclination, or turnover. Therefore, measures to reduce or eliminate risks shall be taken with regard to the types and degrees of biomechanical effects acting on passengers. In order to analyze the risks and possible consequences of failures, it is important to take into account how people are exposed to biomechanical effects and the frequency of such exposure.

Biomechanical effects produced by amusement rides are not always suitable for people with health problems or who are simply not feeling well at the time, and therefore it is necessary to warn people of how extreme the amusement ride may be and of any use limitations.

Types of injuries depending on the severity of harm to the human body can include but are not limited to:

a) Traumatic brain injury (TBI);
b) Vascular injury due to turning upside down;
c) Cardiac arrhythmia due to stress and/or accelerations action;
d) Severe injury of internal organs due to impact;
e) Injury of a musculoskeletal system exposed to high accelerations;
f) Loss of consciousness due to accelerations.

If the safety measures taken are not adequate, any mechanical effects of an **RB-1**value may cause catastrophic harm to the health or life of people. Effects may, for example, include following:

a) Falling from the height of over 8 m;
b) Being hit against an obstacle at a speed higher than 20 m/s;
c) Ejection of an unrestrained passenger;
d) Falling of an unrestrained passenger headlong out of a turned over passenger unit or seat from a height of more than 3 m.

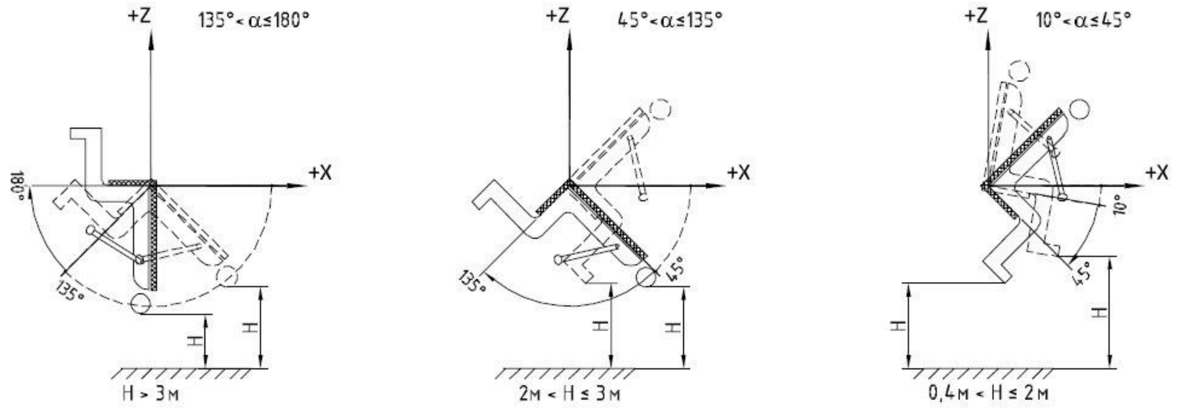
Similarly, any biomechanical effect RB-2 value may cause critical harm to health, including a severe injury or disability, and biomechanical effects of an RB-3 value may cause harm to health such as temporary disorder. It should be noted that, if safety measures are insufficient and any unfavourable events or situations occur in case biomechanical effects may result in high risk which will require risk analysis.

RB-1	the potential of causing fatal harm to a passenger or passengers resulting from biomechanical effects
RB-2	the potential of causing severe harm to the health of a passenger or passengers resulting from biomechanical effects
RB-3	the potential of causing harm with temporary disability of a passenger or passengers resulting from biomechanical effects
RB-4	the potential of causing harm without any form of disability to a passenger or passengers resulting from biomechanical effects

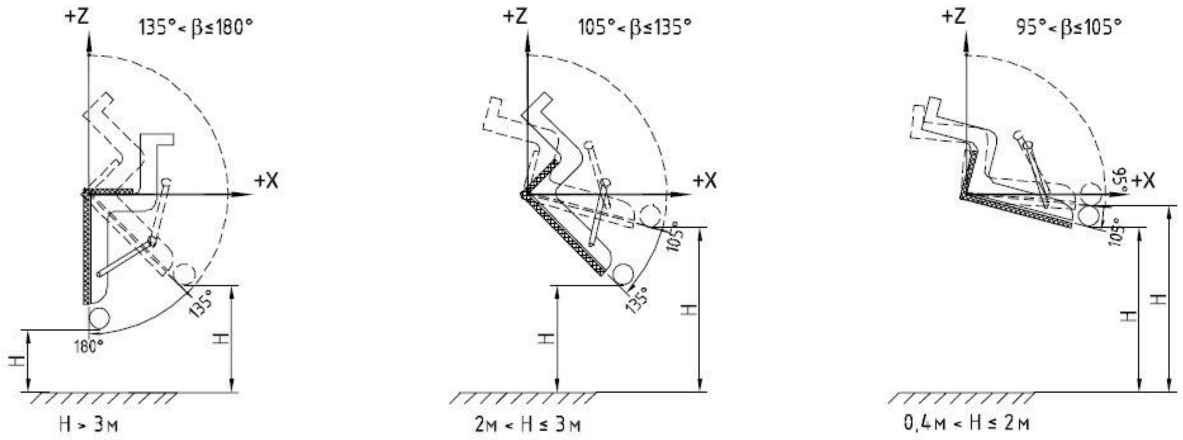
Identification of types and values of effects and degree of potential biomechanical risks shall be performed using Table 8. All figures a) ,b) and c) are given below to illustrate the inclination of types of passenger seats.

Table 8 Types and values of effects to which passengers are exposed and degrees of potential biomechanical risks
(*Clause* 13)

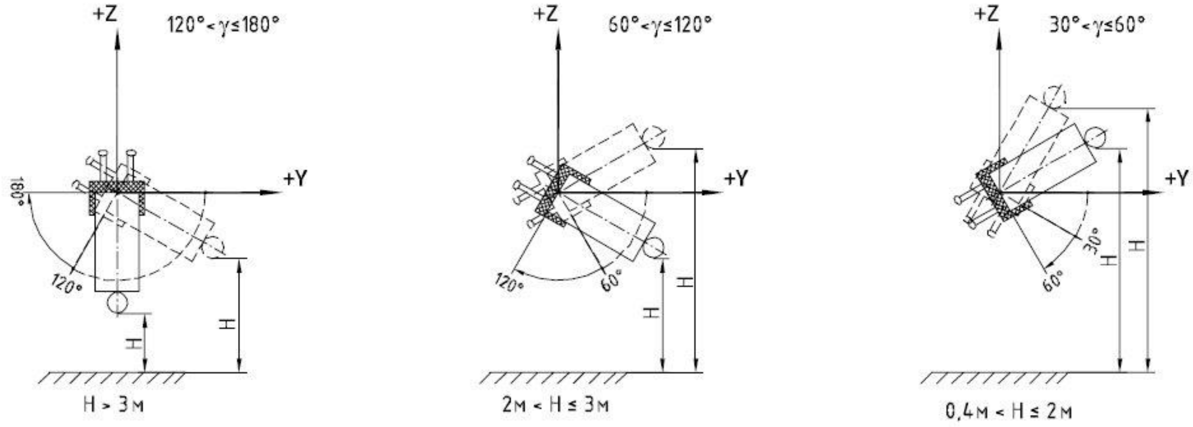
Sl. No.	Type of biomechanical effect	Notation	Degree of potential biomechanical risk			
			RB-1	RB-2	RB-3	RB-4
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Lift to or drop from a relative height	H,m	$H>8$	$2<H\leq 8$	$0.4<H\leq 2$	$H\leq 0.4$
ii)	Travel at a relative velocity	V, m/s	$V>20$	$10<V\leq 20$	$3<V\leq 10$	$V\leq 3$
iii)	Lift of drop in seat with inclination	H,m	$H\geq 3$	$2<H\leq 3$	$0.4<H\leq 2$	$H<0.4$
iv)	-forward inclination (Fig. a)	α, degrees	$135>\alpha\leq 180$	$45<\alpha\leq 135$	$10<\alpha\leq 45$	
v)	-backward inclination (Fig. b)	β, degrees	$135<\beta\leq 180$	$105<\beta\leq 135$	$95<\beta\leq 105$	
vi)	-sideward inclination (Fig. c)	γ, degrees	$120\leq\gamma\leq 180$	$60\leq\gamma\leq 120$	$30<\gamma\leq 60$	



a) Forward inclination



b) Backward inclination



c) Sideward inclination

14 MEASURES FOR ELIMINATION OR REDUCTION OF HAZARDS DUE TO BIOMECHANICAL EFFECTS

Biomechanical risk analysis and risk classification for amusement rides concentrate the attention of those who make and maintain amusement rides on the elements and parameters most important for the safety of amusement rides.

Biomechanical risks arising from the types of effects listed below shall be eliminated or reduced by means of the following basic methods, and the necessity for redundancy depends on the risk analysis:

a) When passengers are at a height of more than 2 m, reliable load-carrying structures and fences with due allowance for wind effects shall be provided as well as appropriate lifts and hoists;
b) When passengers are being moved at a high speed (more than 3 m/s), appropriate containment devices shall be provided to prevent falling or potential ejection of passengers taking into account effects of inertia — measures shall be taken to remove obstacles that may cause harm getting into the relevant motion envelopes of passengers;
c) When passengers are moved with high accelerations comparable with allowable limits for each axis, the passenger’s body shall be secured with restraint in order to ensure that accelerations are safely tolerated and to eliminate the risk of passenger ejection due to acceleration (including under normal and emergency braking);

d) When seats or passenger units are turned over and there is a probability of passengers falling out, appropriate passenger containment shall be provided.

15 RECOMMENDED ACCELERATION LIMITS

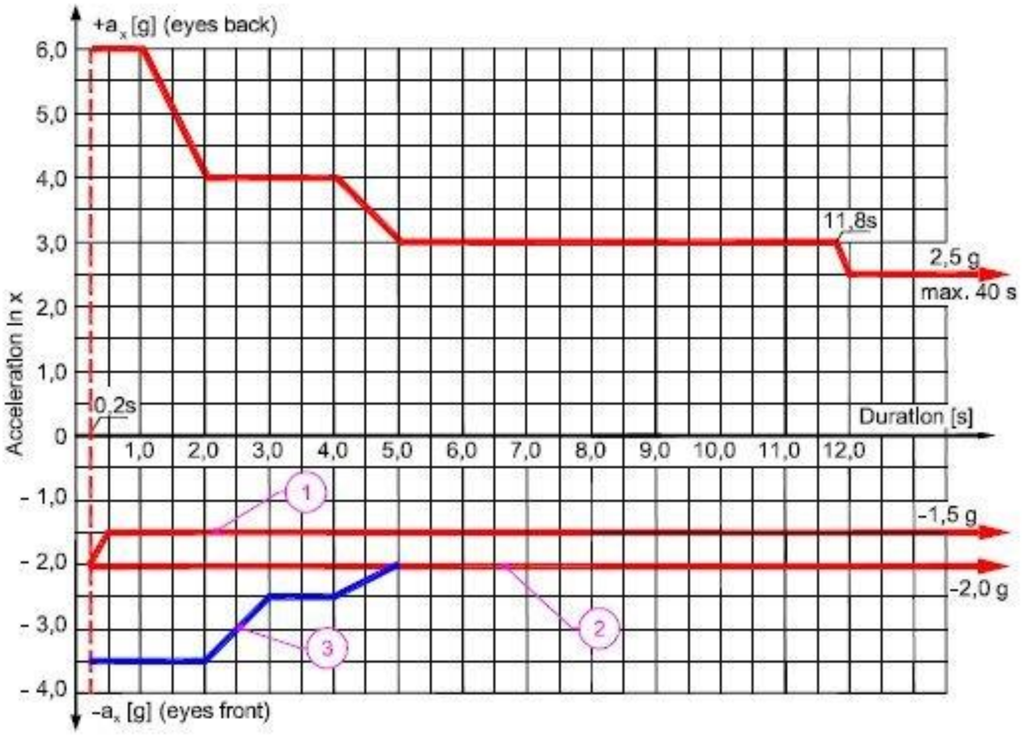
Unfavourable effects of accelerations on the human body may show themselves through the following:

a) Displacement of the body or its parts under inertia forces, collision with surrounding objects and secondary injuries;
b) Deformations of tissues and organs resulting in disorders of blood circulation and respiratory disturbance;
c) The risk of injuries and adverse effects due to accelerations can be minimized by means of the following measures;
d) Application of appropriate passenger containment and restraint;
e) Use limitations for persons with physical restriction or health problems;
f) Application of Cl. 15 for limiting the accelerations to which passengers are exposed on amusement rides.

Accelerations acting on passengers when using amusement rides should be limited to a tolerable level. Recommended acceleration values are given below to ensure the safety of apparently healthy passengers but some values can cause discomfort, for example, motion sickness. Limiting values are given below. For the different directions of accelerations, the passenger coordinate system with orthogonal axes X, Y, and Z as shown in Fig. 10 applies.

The Z-axis direction is defined along the spine (± 5° tolerance).

The time duration limit for allowable acceleration in the X, Y & Z sections are given below:



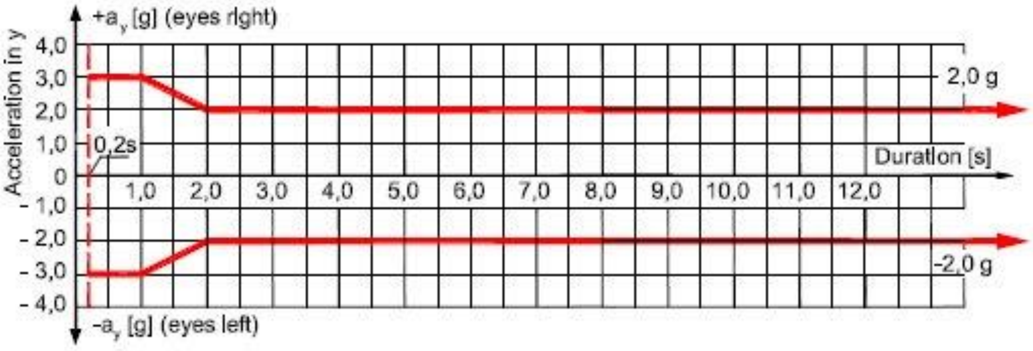
Ke

1 base case

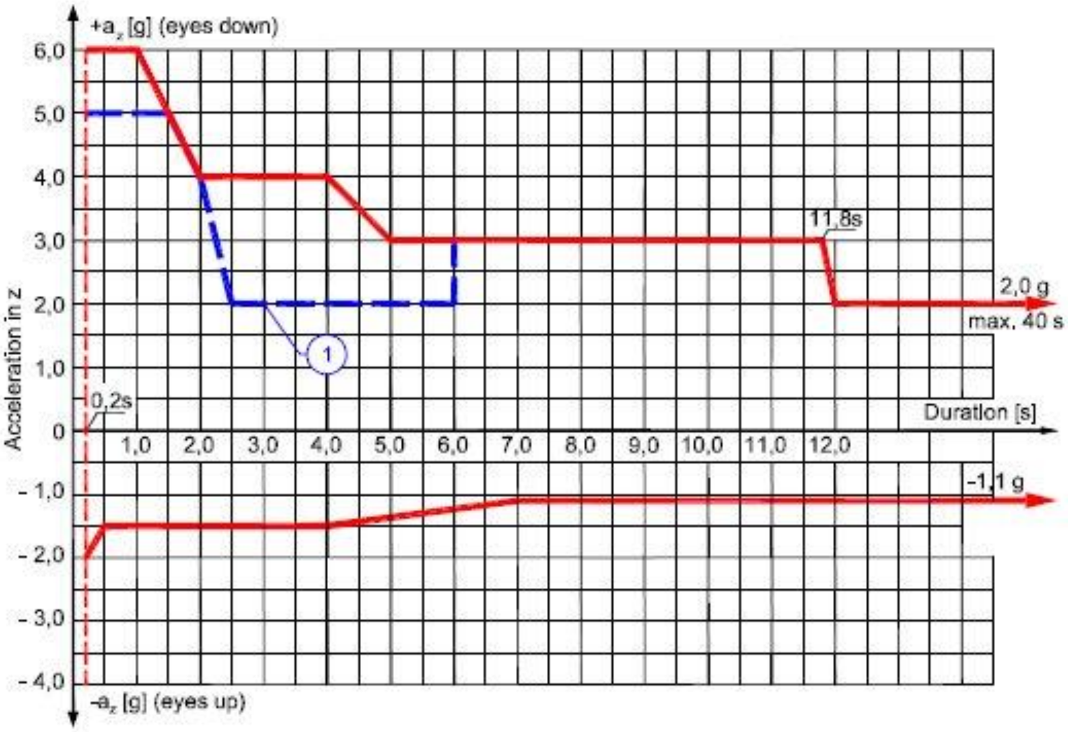
2 over the shoulder restraint

3 prone restraint

Time duration limits for allowable accelerations in X-direction (perpendicular to spine)



Time duration limits for allowable accelerations in Y-direction



Key

1 + Gz limits if preceded by 3 s or more of − Gz

Maximum duration of $+a_z$ (eyes down) = 2,0 g is limited to 40 s.

Time duration limits for accelerations in Z-direction (parallel to spine)

ANNEX A
(*Clause* 2)

LIST OF INDIAN STANDARDS REFERRED

IS No.	*Title*
SP 30 : 2011	National electrical code 2011 (*first revision*)
IS 210 : 2009	Grey iron castings — specification (*first revision*)
IS 399 : 1963	Classification of commercial timbers and their zonal distribution
IS 456 : 2000	Plain and reinforced concrete — code of practice (*fourth revision*)
IS 732 : 2019	Code of practice for electrical wiring installations (*fourth revision*)
IS 734 : 1975	Specification for wrought aluminium and aluminium alloy forging stock and forgings (for general engineering purposes) (*second revision*)
IS 755 : 1984	Specification for handloom cotton MALMAL (*first revision*)
IS 800 : 2007	General construction in steel — code of practice (*third revision*)
IS 802 (Part 1/Sec 1) : 2015	Use of structural steel in overhead transmission line towers — code of practice — part 1 materials, loads and design strengths : Sec 1 materials and loads (*fourth revision*)
IS 802 (Part 1/Sec 2) : 2016	Use of structural steel in overhead transmission line towers — code of practice — part 1 material, loads and permissible stresses : Sec 2 permissible stresses (*fourth revision*)
IS 875 (Part 3) : 2015	Design loads (other than earthquake) for buildings and structures — code of practice — Part 3 Wind loads (*third revision*)
IS 883 : 2016	Design of structural timber in buildings — code of practice (*fifth revision*)
IS 947 : 1985	Specification for washers for water fittings for fire fighting purposes (*second revision*)
IS 1030 : 1998	Carbon steel castings for general engineering purposes — specification (*fifth revision*)
ISO 1204 : 1990	Reciprocating internal combustion engines — Designation of the direction of rotation and of cylinders and valves in cylinder heads, and definition of right hand and left hand in — line engines and locations on an engine
IS 1285 : 2002	Wrought aluminium and aluminium alloys — extruded round tube and hollow sections for general engineering purposes — specification (*third revision*)
IS 1293 : 2019	Plugs and socket - outlets of rated voltage up to and including 250 volts and rated current up to and including 16 amperes —— specification (*third revision*)
IS 1364 (Part 1) : 2018	Hexagon head bolts, screws and nuts of product grades a and b — Part 1 Hexagon head bolts (size range m 1.6 to m 64) (*fifth revision*)
IS 1364 (Part 2) : 2018	Hexagon head bolts, screws and nuts of product grades a and b — Part 2 Hexagon head screws (size range m 1.6 to m 64) (*fifth revision*)

IS No.	*Title*
IS 1364 (Part 3) : 2018	Hexagon head bolts, screws and nuts of product grades a and b — Part 3 Hexagon nuts, style 1 (size range m 1.6 to m 64)
IS 1364 (Part 4) : 2003	Hexagon head bolts, screws and nuts of product grades a and b : part 4 hexagon thin nuts (chamfered) (size range m1.6 to m64) (*fourth revision*)
IS 1364 (Part 5) : 2002	Hexagon head bolts, screws and nuts of product grades a and b : part 5 hexagon thin nuts — product grade b (unchamfered) (size range m1.6 to m10) (*fourth revision*)
IS 1364 (Part 6) : 2018	Hexagon head bolts, screws and nuts of product grades a and b part 6 hexagon nuts, style 2 (*first revision*)
IS 1368 : 2018	Dimensions for ends of parts with external iso metric threads (*fourth revision*)
IS 1641 : 2013	Fire safety of buildings (general) : general principles of fire grading and classification — code of practice (*second revision*)
IS 1642 : 2013	Fire safety of buildings (general) : details of construction — code of practice (*second revision*)
IS 1643 : 2013	Fire safety of buildings (general) : exposure hazard â€” code of practice
IS 1644 : 2013	Fire safety of buildings (general) : exit requirements and personal hazard — code of practice (*second revision*)
IS 1646 : 2015	Fire safety of buildings (general) : electrical installations — code of practice (*third revision*)
IS/ISO 1834 : 1999	Short link chain for lifting purposes — general conditions of acceptance.
IS 1891 (Part 1) : 2021	Conveyor and elevator textile belting — specification part 1 general purpose belting (*fifth revision*)
IS 1891 (Part 2) : 1993	Conveyor and elevator textile belting — specification : part 2 heat resistant belting (*third revision*)
IS 1891 (Part 3) : 1988	Specification for rubber conveyor and elevator textile belting : part 3 oil resistant belting (*second revision*)
IS 1891 (Part 4) : 1978	Specification for rubber conveyor and elevator belting : part 4 hygienic belting (*first revision*)
IS 1891 (Part 5) : 1993	Conveyor and elevator textile belting — specification : part 5 fire resistant belting for surface application
IS 1893 (Part 4) : 2015	Criteria for earthquake resistant design of structures part 4 industrial structures including stack — like structures (*first revision*)
IS 2004 : 1991	Carbon steel forgings for general engineering purposes — specification (*third revision*)
IS 2026 (Part 1) : 2011	Power transformers : part 1 general (*second revision*)
IS 2062 : 2011	Hot rolled medium and high tensile structural steel — specification (*seventh revision*)

IS No.	*Title*
IS 2266 : 2019	Steel wire ropes for general engineering purpose — specification (*fifth revision*)
IS 2361 : 2002	Bulldog grips — specification (*third revision*)
IS/ISO 2415 : 2004	Forged shackles for general lifting purposes — dee shackles and bow shackles
IS 2429 (Part 1) : 1987	Specification for round steel short link chains (electric butt welded), grade l(3) : part 1 non — calibrated load chain for lifting purposes (*third revision*)
IS 2485 : 2022	Specification for drop forged sockets for wire ropes for general engineering purposes (*second revision*)
IS 2535 (Part 1) : 2004	Cylindrical gears for general and heavy engineering : part 1 standard basic rack tooth profile (*third revision*)
IS 2535 (Part 2) : 2004	Cylindrical gears for general and heavy engineering : part 2 module (*third revision*)
IS 2644 : 1994	High strength steel castings for general engineering and structural purposes - specification (*fourth revision*)
IS 2760 : 1980	Specification for steel chain slings (*first revision*)
IS 2762 : 2009	Wire rope slings and sling legs — specification (*second revision*)
IS 2828 : 2019	Plastics — vocabulary (*second revision*)
IS 3043 : 2018	Code of practice for earthing (second revision)
ISO 3046 (part 1) : 2002	Reciprocating internal combustion engines — performance — part 1 : declarations of power, fuel and lubricating oil consumptions, and test methods — additional requirements for engines for general use
IS/ISO 3076 : 2012	Round steel short link chains for general lifting purposes — medium tolerance sling chains for chain slings — grade 8 (*first revision*)
IS/ISO 3077 : 2001	Short link chain for lifting purposes — grade T(types T, oat and Dt), fine — tolerance hoist chain
IS 3109 (Part 1) : 1982	Specification for short link chain, grade m (4) : part 1 non — calibrated load chain for lifting purposes (*second revision*)
IS 3629 : 1986	Structural timber in building — specification
IS 3734 : 1983	Dimensions of worm gearing (*first revision*)
IS 3757 : 1985	Specification for high strength structural bolts (*second revision*)
IS 3809 : 1979	Fire resistance test for structures
IS 3854 : 1997	Switches for domestic and similar purposes — specification (*second revision*)
IS 3871 : 2013	Fibre ropes and cordage — vocabulary (*third revision*)
IS 4889 : 1968	Methods of determination of efficiency of rotating electrical machines

IS No.	*Title*
IS 4912 : 1978	Safety requirements floor and wall openings, and toe boards (*first revision*)
IS 5037 (Part 1) : 2004	Straight bevel gears for general engineering and heavy engineering : part 1 basic rack (first revision)
IS 5037 (Part 2) : 2004	Straight bevel gears for general engineering and heavy engineering : part 2 module and diametral pitches (*first revision*)
IS 5175 : 2014	Fibre ropes — polypropylene split film, monofilament and multifilament (pp2) and polypropylene high — tenacity multifilament (pp3) — 3 — ,4 — ,8 — and 12 — strand ropes (*third revision*)
IS 5384 : 1985	Aluminium i — beam
IS 7651 : 2021	Wire reinforced rubber covered hydraulic hose specification third revision of is 7651
IS 8147 : 1976	Code of practice for use of aluminium alloys in structures
IS 8526 : 1994	Sizes for bores and port threads for pneumatic fluid power cylinders — recommendations (*first revision*)
IS 9282 : 2021	Wire ropes and strands for suspension bridges
IS 9833 : 2018	List of colourants for use in plastics in contact with foodstuffs and pharmaceuticals (*second revision*)
IS 9936 : 1992	Manila, nylon, polyester and polypropylene ropes for marine purpose — guide on equivalence (*first revision*)
IS 10000 (Part 1 to 13) : 1980	Methods of tests for internal combustion engines
IS 10143 : 1995	Pneumatic fluid power — single rod cylinders, 1 000 kpa (10 bar) series with detachable mountings, bores from 32 mm to 320 mm — mounting dimensions (*first revision*)
IS 11277 : 2004	Hydraulic fluid power-gas-loaded accumulators with separator - ranges of pressures and volumes and characteristic quantities (*first revision*)
IS 11066 : 2014	Fibre ropes — polyester 3 — ,4 — ,8 — and 12 — strand ropes (*second revision*)
IS 12723 : 2020	Pneumatic fluid power — single rod cylinders, 1 000 kpa (10 bar) series, bores from 8 mm to 25 mm — basic and mounting dimensions (*first revision*)
IS 12725 : 2021	Pneumatic fluid power — general rules and safety requirements for systems and their components (*second revision*)
IS 12738 : 1995	Pneumatic fluid power 7 single rod cylinders, 1 000 kpa (ib 10 bar) series, with integral mountings, bores from 32 mm to 250 mm — mounting dimensions (*first revision*)
IS 13086 : 2021	Pneumatic fluid power — cylinders, 1 000 kpa (10 bar) series — mounting dimensions of rod — end spherical eyes (*second revision*)
IS 13087 : 2021	Pneumatic fluid power — cylinders, 1 000 kpa (10 bar) series — mounting

IS No.	*Title*
	dimensions of rod — end clevises (*second revision*)
IS 13980 : 1995	Acceptance tests on industrial boilers - code of practice
IS 14534 : 2016	Plastics — guidelines for the recovery and recycling of plastics waste (*first revision*)
IS 15475 (Part 1) : 2022	Code of recommended practice for amusement rides safety : part 1 general information
IS/IEC 61558-1 : 1997	Safety of power transformers, power supply units and similar : part 1 general requirements and tests
IS 62305 (Part 1) : 2010	Protection against lightning : part 1 general principles
IS/IEC 62305(Part 2) : 2010	Protection against lightning : part 2 risk management
IS/IEC 62305(Part 3) : 2010	Protection against lightning : part 3 physical damage to structures and life hazard
IS/IEC 62305(Part 4) : 2010	Protection against lightning : part 4 electrical and electronic systems within stuctures
ISO 683 (Part 1) : 2016	Heat-treatable steels, alloy steels and free-cutting steels — Part 1 : Non-alloy steels for quenching and tempering

ANNEX B

(*Clause* 10.5.1, 10.5.3, 10.5.6, 10.12.1)

LIST OF INDIAN STANDARDS ON WELDING

The following listed standards, contain provisions which, through their reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards:

IS No.	*Title*
IS814 : 2004	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel — specification (*sixth revision*)
IS816 : 1969	Code of practice for use of metal arc welding for general construction in mild steel (*first revision*)
IS817 (Part 1) : 1992	Training of welders — code of practice : part 1 manual arc welding (*second revision*)
IS817 (Part 2) : 1996	Training of welders — code of practice : part 2 oxyfuel welding (*second revision*)
IS818 : 1968	Code of practice for safety and health requirements in electric and gas welding and cutting operations (*first revision*)
IS819 : 1957	Code of practice for resistance spot welding for light assemblies in mild steel
IS822 : 1970	Code of procedure for inspection of welds
IS1278 : 1972	Specification for filler rods and wires for gas welding (*second revision*)
IS1395 : 1982	Specification for low and medium alloy steel covered electrodes for manual metal arc welding (*third revision*)
IS4972 : 1968	Specification for resistance spot — welding electrodes
IS5856 : 2017	Welding consumables — wire electrodes, strip electrodes, wires, and rods for arc welding of stainless and heat resisting steels — classification (*second revision*)
IS5897 : 1985	Specification for aluminium and aluminium alloy welding rods and wires and magnesium alloy welding rods (*first revision*)
IS5898 : 1970	Specification for copper and copper alloy bare solid welding rods and electrodes`
IS6419 : 1996	Welding rods and bare electrodes for gas shielded arc welding of structural steel (*first revision*)
IS6560 : 2017	Welding consumables — wire electrodes, wires, rods and deposits for gas shielded arc welding of creep — resisting steels — classification (*second revision*)
IS 15977 : 2013	Classification and acceptance tests for bare solid wire electrodes and wire flux combination for submerged arc welding of structural steel — specification

ANNEX C

(*Clause* 10.12.1, 10.13.1)

LIST OF INDIAN STANDARDS ON ELECTRICAL SYSTEM

The following listed standards, contain provisions which, through their reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards:

IS No./SP	*Title*
SP 31 : 1986	Treatment for electric shock
IS 900 : 2019	Code of practice for storage, installation and maintenance of induction motors (*third revision*)
IS 2551 : 1982	Danger notice plates (*first revision*)
IS 2705 (Part 1) : 1992	Current transformers — specification : part 1 general requirements (*second revision*)
IS 3043 : 2018	Code of practice for earthing (*second revision*)
IS 5216(Part 1) : 1982	Recommendations on safety procedures and practices in electrical work : part 1 general (*first revision*)
IS 5216(Part 2) : 1982	Recommendations on safety procedures and practices in electrical work : part 2 life saving techniques
IS 5578 : 1984	guide for marking of insulated conductors (*first revision*)
IS 7098 (Part 1) : 1988	Specification for cross — linked polyethylene insulated PVC sheathed cables : Part 1 for working voltages up to and including 1100 volts (*first revision*)
IS 7098 (Part 2) : 2011	Cross — linked polyethylene insulated thermoplastic sheathed cables — Specification : Part 2 for working voltages from 3.3 kV up to and including 33 kV (*second revision*)
IS 7098 (Part 3) : 1993	Cross — Linked polyethylene insulated thermoplastic sheathed cables — Specification : Part 3 for working voltages from 66 kV up to and including 220 kV
IS 7689 : 1989	Guide for the control of undesirable static electricity (*first revision*)
IS 8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650V
IS 8884 : 1978	Code of practice for the installation of electric bells and call system
IS 9409 : 1980	Classification of electrical and electronic equipment with regard to protection against electric shock
IS 10028 (Part 1) : 1985	Code of practice for selection, installation, and maintenance of transformers : part 1 selection
IS 10028 (Part 2) : 1981	Code of practice for selection, installation, and maintenance of transformers : Part 2 installation

IS No./SP	*Title*
IS 10028 (Part 3) : 1981	Code of practice for selection, installation, and maintenance of transformers : Part 3 maintenance
IS 11353 : 1985	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS 12065 : 1987	Permissible limits of noise level for rotating electrical machines
IS 12615 : 2018	Line operated three phase AC motors (IE code) "efficiency classes and performance specification" (*third revision*)

Lightning Arrestor

IEC 60099 (part 4) : 2014	Surge arresters — Part 4 : Metal — oxide surge arresters without gaps for A.C. systems
IS 3070 (part 3) : 1993	Lightning arresters for alternating current systems, part 3 : metal oxide lightning arresters without gaps

Tools and Equipment for Live Working

IS 13772 : 2021	Live working hand tools for use up to 1 000 V AC and 1 500 V DC (*second revision*)
IS 13773 : 2018	Live working - electrical insulating sleeves (*first revision*)
IS 13774 : 2021	Live working gloves of insulating material (*second revision*)
IS 13961 (Part 1) : 2018	Live working — insulating sticks and attachable devices : part-1 : insulating sticks
IS 13961 (Part 2) : 2017	Live working — insulating sticks and attachable devices : part-2 attachable devices (*first revision*)

Electrical Welding Equipment

IS 1851 : 1997	Single operator type arc welding transformers — specification
IS 2635 : 1997	DC electric welding generators — specification (*third revision*)
IS 2641 : 1989	Electric welding accessories — specification (*first revision*)
IS 4804 (Part 1) : 1968	Resistance welding equipment : Part 1 single — phase transformers
IS 7931(Part 1) : 1975	Specification for automatic and semi — automatic welding equipment with self — adjusting arcs (MIG/MAG processes) : part 1 DC welding generator power source
IS 7931 (Part 2) : 1975	specification for automatic and semi — automatic welding equipment with self — adjusting arcs (MIG/MAG processes) : part 2 transformer — rectifier power source
IS 7931 (Part 3) : 1975	Specification for automatic and semi — automatic welding equipment with self — adjusting arcs (MIG/MAG processes) : part 3 welding gun and ancillary equipment

IS No./SP	*Title*
IS 8804 : 1993	Plugs, sockets, terminal arrangements and welding cable connectors for manual welding equipment - specification (*first revision*)
IS 9604 : 1994	Tungsten — inertgas (TIG) welding equipment — specification (*first revision*)
IS 9857 : 1990	Welding cables — specification (*first revision*)

ANNEX D

(*Clause* 10.13.1)

LIST OF INDIAN STANDARDS ON DIESEL ENGINE, COUPLING, BEARING, PNEUMATIC TYRES, WIRE ROPES, FLUID POWER SYSTEMS AND HYDRAULIC COMPONENTS

The following listed standards, contain provisions which, through their reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards:

IS No.	*Title*
IS2693 : 1989	Power transmission bush type flexible coupling (*second revision*)
IS 3090 : 1965	Code of practice for installation and maintenance of rolling bearings
IS 3823 : 2014	Rolling bearings — Static load ratings (*third revision*)
IS 6455 : 2020	Single row deep groove ball bearings — specification (*first revision*)
IS 8383 : 2017	Hydraulic fluid power — filter elements — verification of fabrication integrity and determination of the first bubble point (*second revision*)
IS 9269 : 2019	Hydraulic fluid power-filters-evaluation of differential pressure versus flow characteristics (*second revision*)
IS10000 (Part 1 to 13) : 1980	Methods of tests for internal combustion engines
IS10001 : 1981	Performance requirements for constant speed compression ignition (diesel) engines for general purposes (up to 20 kW)
IS 10069 : 2017	Hydraulic fluid power-positive displacement pumps, motors and integral transmission-methods of testing and presenting basic steady state performance (*second revision*)
IS 10187 : 2013	Hydraulic fluid power — four — port directional control valves — mounting surfaces (*second revision*)
IS 10481 : 2020	Hydraulic fluid power — general rules and safety requirements for systems and their components *(second revision*)
IS 10891 (Part 1) : 2001	Steel wire ropes for aerial ropeways — specification : part 1 haulage ropes (*first revision*)
IS 10891 (Part 2) : 2018	Specification for steel wire ropes for aerial ropeways : part 2 track ropes
IS 11003 (Part 1) : 2017	Hydraulic fluid power — mounting dimensions for single rod cylinders, 16 MPa (160 Bar) series : part 1 medium series (*second revision*)
IS 11003 (Part 2) : 2020	Hydraulic fluid power — mounting dimensions for single rod cylinders, 16 MPa (160 Bar) series part 2 compact series (*second revision*)
IS11559 : 1995	Hydraulic fluid power — cylinders — rod end spherical eyes — mounting dimensions (*first revision*)
IS 11560 : 1995	Hydraulic fluid power — cylinders — rod end plain eyes — mounting dimensions

IS No.	*Title*
	(*first revision*)
IS12102 : 1987	Specification for tapered roller bearings
IS12593 : 2000	Hydraulic fluid power — single rod cylinder 16 MPa (160 Bar) compact series — tolerances (*first revision*)
IS13053 : 1991	Hydraulic fluid power system commissioning and maintenance of complete hydraulic systems recommendations
IS13085 : 1991	Hydraulic fluid power — single rod cylinders, 160 bar (16 MPa) medium series — port dimensions
IS 13103 : 2005	Hydraulic fluid power — single rod cylinders, 16 MPa (160 Bar) compact series — Port dimensions (*first revision*)
IS 13251 : 2019	Hydraulic fluid power — mounting dimensions for accessories for single rod cylinders, 16 MPa (160 Bar) medium and 25 MPa (250 Bar) series (*first revision*)
IS 13405 : 2018	Rolling bearings — cylindrical roller bearings, separate thrust collars — boundary dimensions (*second revision*)
IS 13569 : 1993	Hydraulic fluid power — fluid sample containers — qualifying and controlling cleaning methods
IS13570 : 2000	Hydraulic fluid power — particulate contamination analysis — extraction of fluid samples from lines of an operating system (*first revision*)
IS 13656 : 2019	Internal combustion engine crankcase oils for automotive application (diesel and gasoline) — specification (*third revision*)
IS 14148 : 2021	Hydraulic fluid power — pressure — reducing valves, sequence valves, unloading valves, throttle valves and check valves — mounting surfaces (*second revision*)
IS 14150 : 2005	Hydraulic fluid power — pressure relief valves — mounting surfaces (*first revision*)
IS 14601 : 1998	Method for presenting performance data for hydraulic pumps
IS 14604 : 1998	Proforma for purchase specification for positive displacement pumps and motors used in oil hydraulic systems
IS15627 : 2005	Automotive vehicles — pneumatic tyres — two and three — wheeled motor vehicles — specification
IS15633 : 2005	Automotive vehicles — pneumatic tyres for passenger car vehicles diagonal and radial ply — specification
IS15636 : 2012	Automotive vehicles — pneumatic tyres for commercial vehicles — diagonal and radial ply — specification (*first revision*)

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

Continuous Bulk Conveying, Elevating, Hoisting Aerial Ropeways and Related Equipment Sectional Committee, MED 06

Organization	*Representative(s)*
RITES Limited, Gurugram	Shri Sandeep Mehra (***Chairman***)
CSIR — Central Institute for Mining and Fuel Research, Dhanbad	Shri Debashish Basak Shri Girendra M. Prasad (*Alternate*)
Conveyor and Ropeway Services Private Limited, Kolkata	Shri S. Shekhar Chkravarty Shri Kamal Kumar Bose (*Alternate*)
Desein Private Limited, New Delhi	Shri H. K. Gupta Shri Arvinder Singh (*Alternate*)
Directorate General Factory Advice Service and Labour Institutes, Mumbai	Shri G. P. Nijalingappa Shri H M Bhandari (*Alternate*)
Directorate General of Mines Safety, Dhanba	Shri D. B. Nayak Shri Vijay Yadaorao Barapatre (*Alternate*)
Durgapur Steel Plant, Sail Durgapur	Shri Sanjay Kumar Shri Deepak Biswal (*Alternate*)
Elecon Engineering Company Limited, Gujarat	Shri C. S. Shah Shri K.S. Kodia (*Alternate*)
Indian Association of Amusement Parks and Industries, Mumbai	Shri Pradeep Sharma Shri Anil Padwal (*Alternate*)
Lepton Projects Private Limited, Ghaziabad	Shri Sanjay Kumar Shri Piyush Rathi (*Alternate*)
MECON Limited, Ranchi	Shri Sanjoy Bhattachar Shri Amit Pal (*Alternate*)
Mcnally Bharat Engineering Company Limited, Kolkata	Shri Sanjoy Maiti Shri Sandipan Daw (*Alternate*)
Ministry of Ports, Shipping and Waterways, New Delhi	Shri Anil Pruthi Shri Ramji Singh (*Alternate*)
NTPC Limited, New Delhi	Shri O. P. Kalia
National Mineral Development Corporation, Hyderabad	Shri Alok Kumar Mehta Shri S. Surender (*Alternate*)
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